Popular Astronomy.

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VARIABLE STARS IN THE CLUSTER M 11 (N. G. C. 6705).

E. E. BARNARD.

I have found on my photographs of the cluster M 11 made with the 40-inch telescope, one variable star, and probably another. They are in the positions:

1	1900.0	α	18^h	45^m	$47^s.58$	δ	$-6°$	$15'$ $22''.2$
2			18	45	38.27		-6	19 47.7

Variable No. 1 is shown on two plates at or near its maximum brightness, 1912 June 9 and 1916 July 5, when it was about 14th magnitude. At minimum it must be below 16th magnitude. At present it is visible in the 40-inch telescope and seems to be brightening. It is not shown on the following dates:

1910 July 3	14½ mag.	1919 June 17	15 mag.
1916 April 8	15 mag.	1919 June 21	14½ mag.

Variable No. 2 is shown on only one plate, 1919 June 17, when it was of about 13½ magnitude. I do not find any star at its place with the 40-inch, but the image is so exactly like the other stars of the same brightness on the plate that I feel sure it is real. It is 10″ south following a much brighter star.

Professor Bailey has kindly verified Variable No. 1 on the H.C.O. plates, five of which are available for comparison. He does not find No. 2 on any of the plates. Both stars (if we count No. 2) are probably long-period variables that go through a large range of magnitude. No. 1 certainly has a range of over two magnitudes. The period is not a short one.

Professor Bailey's notes for these stars, with which he has kindly supplied me, are:

Date	Exp.	Variable No. 1	Variable No. 2
1895 July 20	90	Not seen.	Not seen.
1895 July 25	80	Faint trace.	Not seen.
1896 June 17	69	Not seen.	Not seen.
1897 Oct. 23	90	Clearly seen.	Not seen.
1899 Aug. 3	90	Not seen.	Not seen.

"Variable No. 1 is confirmed with a range of at least a magnitude. Variable No. 2 is not seen on any plate."

The following are visual measures which I have made of the seven stars shown in the diagram for Variable No. 1, where V is the variable.

		P. A.	Dist.	
A—B	1919.526	141°.4	231″.1	(2 n)
B—*a*	1919.506	331.0	125.6	(3 n)
B—*b*	1919.496	326.5	98.9	(2 n)
B—*c*	1919.503	332.4	75.5	(1 n)
B—*d*	1919.503	332.4	149.4	(1 n)
V—*a*	1919.551	3.1	20.7	(2 n)

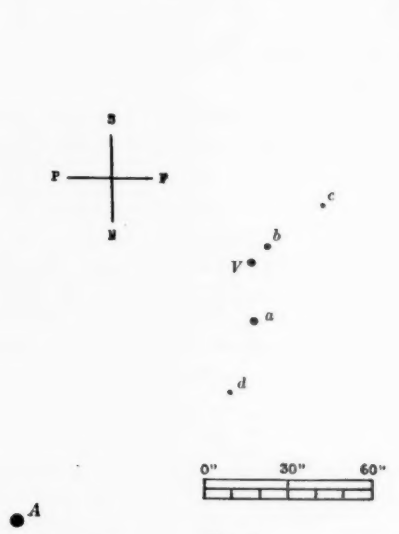


FIG. 1
Diagram showing the position of Variable No. 1.

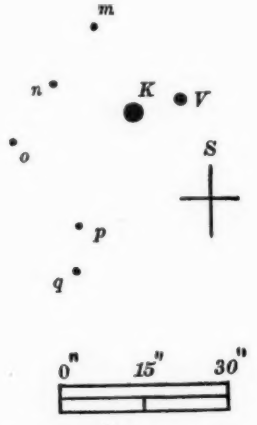


FIG. 2
Diagram showing the position of the probable Variable No. 2.

There is a 16½ magnitude star 5″ north of *c*. I have measured the position of B:

1900.0 α 18^h 45^m 51^s.74, δ −6° 16′ 51″.6. (13^m.2)

I have also determined the position of K, which is shown in Figure 2.

1900.0 α 18^h 45^m 37^s.63, δ −6° 19′ 42″.4. (13^m)

"Variable No. 2 is, roughly, with respect to K, in P. A. 109°±, Dist. 9½″±.

The earlier of the two photographs was made with a thinner color-screen than the other. This accounts for the larger star images.

Yerkes Observatory, Williams Bay, Wisconsin.
August 14, 1919.

ON THE VARNISHING OF ASTRONOMICAL NEGATIVES.

E. E. BARNARD.

The preservation of original astronomical negatives is of vital importance. There are three things that tend to the injury or total destruction of dry plate negatives:

1) Deterioration due to the atmosphere.
2) Deterioration due to insufficient fixing in the hypo.
3) Deterioration due to insufficient washing.

The most harmful of these, and the one for which there seems to be no remedy, is insufficient fixing. The want of complete washing, when detected in time, can be remedied by rewashing, if the negative has not been varnished. The effect of atmospheric deterioration is slow. It can be prevented by varnishing the negative. The varnishing of the old wet plate negatives was imperative because the collodion film was very delicate and the negative could not be printed from until it was protected by a coat of varnish. The collodion film was also very soon subject to deterioration from exposure to the air. When varnished, the film was hermetically sealed and unless it contained some destructive chemical element, was preserved with certainty for a great length of time. I have in my possession wet plate negatives so varnished that are fifty years old. Apparently they have suffered no change in the mean time.

In *Lick Observatory Publications*, Vol. XI, p. 15, I have called attention to the importance of varnishing negatives. In some of the comet pictures made at the Lick Observatory which I had varnished, the corners of the plates, not completely covered, show a very marked deterioration of the film, while the varnished portion is unchanged. The varnish also produces a hard surface which protects the negative from ordinary rubbing or scratching.

The varnishing of a negative is a simple process. Commercial varnish, specially made for the purpose, can be bought of any photographic stock dealer. A good varnish is "Adamantine" made specially for dry plate negatives by the American Aristotype Company. Seen in the bottle this is of a deep golden color. When applied to the plate, however, it is almost colorless and does not in any way effect the quality of the negative.

To those unfamiliar with the process of varnishing a negative, it may perhaps be well to explain the method that I have used, which was that employed in the old wet plate days. It seems to need no change for the negative of today. The varnish can be poured from the

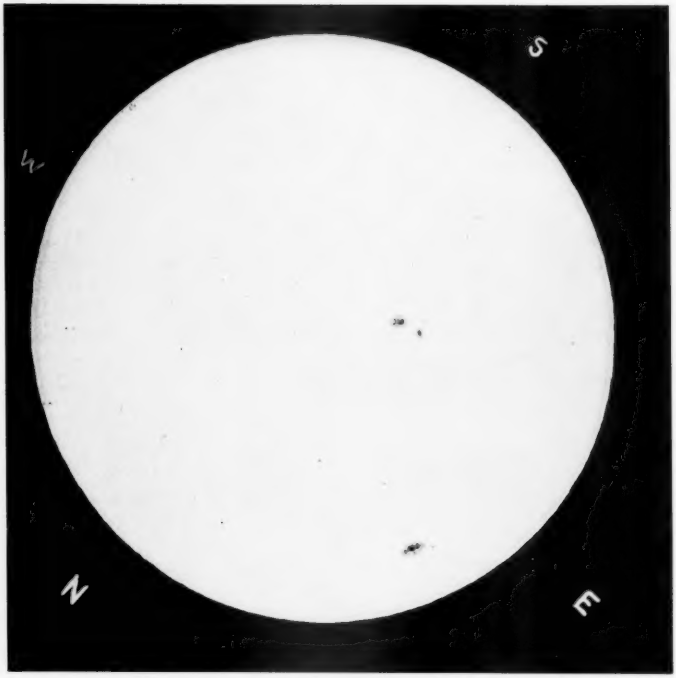
original bottle. It should not be applied with a brush on the ordinary negative. Hold the negative, with film up, between the thumb and forefinger of the left hand. Pass it rapidly over a source of heat so that it may be heated uniformly. The ordinary kerosene lamp with glass chimney is suitable, but a broader heating surface may be devised when many negatives are to be varnished. When the negative is quite warm (it should be very warm), as indicated by touching the under surface with the back of the right hand, hold the plate horizontal. Now pour from the bottle upon the plate near its farther right hand corner an ounce or so of the varnish; then incline the plate so that the varnish will flow to the left hand side, giving a base from which, by further changing the position, it will sweep in a broad flow over the entire plate, flowing off at the nearer right-hand corner, where the varnish can be poured into another bottle, to be used again, with a tin funnel in which is a wad of absorbent cotton to act as a filter. Before heating and applying the varnish the negative should be carefully dusted with a broad camel's-hair brush. The heating of the plate is to insure the freedom of the film from any moisture. It also causes the varnish to dry quicker and more brilliantly. When the varnish ceases to drain from the negative, the plate should again be held over the source of heat until it is dry, which will take less than a minute. When so held (it should be moved rapidly about so that the heat acts uniformly or the negative may break) the surface will be seen to dry rapidly in a wave towards the corner where the varnish was poured off. When this reaches the corner, the plate is dry and should be put aside in a rack for half an hour or so to further harden. There must be no hesitation in the flow of the varnish over the negative, or a ridge will occur in the drying. The varnish is inflammable and the varnishing should not be done over an open flame where there is a chance of its catching fire. Should such an accident occur the burning varnish can be instantly blown out and the negative revarnished. If there is any possible danger of change of the film through expansion in plates that are to be measured, the negative can be allowed to cool again before the varnish is applied. With a cold negative there is a possibility of the varnish having, when dry, a dull surface, like ground-glass. Such a negative can be heated and revarnished and the dullness will disappear. If by chance any varnish should get on the glass side of the negative, it can be removed with alcohol on a piece of cloth or cotton.

In the hope of protecting my negatives of stars and comets from atmospheric injury, I began some time ago to varnish them. It is hoped ultimately to varnish all of them. Perhaps a hundred 8x10 plates can be varnished in an afternoon.

The Varnishing of Spectrograms.

In speaking on the subject with Professor Frost it was concluded that the best method of varnishing spectrograms, where the surface

PLATE XXXVII



THE SUN

Photographed with an unsilvered 10-inch Speculum stopped down to 2 inches.
June 14, 1919, $1^h\ 30^m$ G.M.T. Orientation approximate.

to be covered is very narrow, would be to apply the varnish with a small camel's-hair brush, say ½-inch wide. One sweep of this (the brush containing only a small amount of varnish) would cover the small strip containing the exposure, which is all that is necessary to be protected. By this means hundreds of spectrograms could be varnished in a day. These could be warmed before applying the varnish, by laying them on an electrically heated surface—not too hot. The drying would be done spontaneously.

It may be required to varnish films. There seems no objection to this. The films may be clipped to a piece of glass before varnishing. The celluloid, from which the film is made, is explosive; care must therefore be taken in the warming of the film so that it may not become too hot or be ignited by an open flame.

Yerkes Observatory,
Williams Bay, Wisconsin.
August 16, 1919.

AN UNSILVERED MIRROR FOR THE SUN.

LATIMER J. WILSON.

The separating power of a telescope and not its maximum light collecting quality is what is required for the usual observation, photographic and visual of the Sun. Having at hand an unmounted ten-inch speculum the silver was removed from the surface and the mirror has since been serviceable for occasional views and photographs of the Sun's disc.

Only about four per cent of the light is reflected from an unsilvered glass speculum. The mirror propped against the back of a chair was used in the room as a telescope, the eyepiece of low power fitted with a shade glass being held in the focus. If one's hand is not steady enough for this purpose another chair-back or a camera tripod can be used as a means by which the hand can be steadied. Splendid views of the Sun can be obtained by this slipshod method if one has not a more suitable arrangement.

During June of this year, 1919, the Sun was afflicted with numerous spots. Having no other means of obtaining a record of this interesting phenomenon, the unmounted unsilvered speculum was used in the manner described. For photography the aperture was necessarily reduced to about two inches to accommodate the speed of the focal-plane shutter of a graflex camera from which the lens had been removed. The

image formed on the ground glass was too bright to be seen safely, so a piece of dense yellow filter was placed in front of the ground glass, the image being reflected by a flat mirror in this type of camera. Holding the camera so it was as close as possible to the optical axis of the speculum, the solar disc was sharply focussed on the ground glass and the exposure of 1/1000th of a second given. Double coated plates were found the best and bromide was used to hold back the development of the slightly overexposed image.

ACCURATE TIME FROM THE U. S. NAVAL OBSERVATORY SIGNALS.

CHARLES CLAYTON WYLIE.

(Communicated by Rear Admiral J. A. Hoogewerff, U. S. N., Superintendent, U. S. Naval Observatory.)

Accurate time, distributed by the U. S. Naval Observatory signals, is now furnished the greater part of the United States. Hence, independent time determination is necessary only in special cases. Of those using accurate time, some receive the signals by wireless; some by a private line from a telegraph office; some arrange to hear by telephone the beat of a sounder in a nearby telegraph office; while others take a watch to where the signal can be received, and use the watch to carry the time.

Where the signals can be received directly, a good mean time clock can be kept very close to true time by keeping its beat in coincidence with the time signals. The clock can be accelerated or retarded by touching the pendulum. Some may prefer the method of keeping small weights on the pendulum, and adding or removing a few to keep the clock correct. If the clock is sealed the same result can be attained by varying the air pressure.

Rating a Sidereal Timepiece.

The correction of a clock running on local sidereal time can be obtained almost as easily as that of a mean time clock, provided it is properly compared. As pointed out in P. A. **26**, 23, 1918 January, advantage can be taken of the fact that where a given observatory regularly receives a certain time signal, two quantities are constant for all dates on which signals are received, the longitude of the observatory and the mean time of the signal. Consequently, the reduction from Greenwich sidereal time of mean noon, given in the Ephemeris, to local sidereal time of the mean time hour on which the signal is sent out is constant.

For example: The standard sidereal chronometer of the U. S. Naval Observatory Eclipse Party, stationed at Baker, Oregon, was compared regularly by chronograph with the telegraphic time signals received from Mare Island at noon, Pacific time, according to the summer schedule, or briefly, 7^h Greenwich mean time; so we have

Mean time interval	+	7^h	0^m	$0^s.00$
Table III (Ephemeris)	+		1	9.00
Longitude station	—	7	51	23.01
Reduction	—	0	50	14.01

The chronometer was compared frequently enough to neglect the minute in a comparison. The necessary steps were then: Find in the Ephemeris the Greenwich sidereal time of mean noon of date. From the tabulated seconds mentally subtract 14.01. The resulting quantity is recorded as the local sidereal time of 7^h G.M.T. From this subtract the chronometer time of 7^h G.M.T. according to the chronograph record of the signal. The result is the correcton to the chronometer, according to the signal.

Carrying Time on a Watch.

Observatories not equipped with wireless, or a private loop with which to receive the telegraphic signals, and unable to arrange to hear the latter by telephone, are often near enough to a telegraph office to carry the time on a watch. The writer knows of an accurate sidereal clock, the correction and rate of which were determined from the telegraphic time signals as follows:

A watch was taken to the telegraph office, and, just before the signal was due, the balance was touched delicately to stop the second hand over 60 as accurately as possible. The minute hand was set on the hour and the watch started at the beginning of the final long break of the signal. It was then carried back to the sidereal clock and compared. Some who do not object to an error of a second or so may prefer this setting of a watch by the signal. If the clock used as standard is a mean time it can then be set with the watch. Any who are interested can test the accuracy of this method by setting the watch, say at two minutes before the hour, and comparing it with the remainder of the signal. A little experimentation will probably convince one that the error in thus setting a watch is much greater than that of a single comparison. Other defects in the accuracy of this method will probably occur to the reader.

Before coming to the U. S. Naval Observatory the writer kept a record of the correction and rate of a sidereal clock for over a year. Being near a Western Union office, the time signals were used more than observations. The following example, a comparison made at the U. S. Naval Observatory, 1918 June 18, will illustrate the method developed. Nine comparisons of the 17-jewel watch, U. S. N. 1758, with clock, Howard Sidereal 404, were made on 0^s and 30^s by the clock.

recording the reading of the watch to $0^s.1$. The mean of eight comparisons, the middle one being omitted to eliminate eccentricity, is

Howard 404				U. S. N. 1758		
15^h	30^m	0^s	=	14^h	52^m	$44^s.95$

The watch was then carried in the pocket of the observer for about four minutes, and compared with the 15^h G.M.T. time signal, giving the correction,

U. S. N. 1758 = $-46^s.3$

After the signal the watch was compared as before with Howard 404, the mean of the eight comparisons being,

Howard 404				U. S. N. 1758		
15^h	45^m	0^s	=	15^h	7^m	$42^s.46$

The local sidereal time of 15^h G.M.T. on 1918 June 18 is obtained by adding $9^h\ 54^m\ 12^s.07$ to the Ephemeris Greenwich sidereal time of mean noon. Only the second need be recorded if the correction to the clock is known, as it usually is, within a few seconds.

	Before			After		
Watch	14^h	52^m	$44^s.95$	15^h	7^m	$42^s.46$
Correction			-46.3			-46.3
G.M.T		51	58.65		6	56.16
M.T. interval to 15^h		8	1.35		6	56.16
Table III			$+1.32$			$+1.14$
Sidereal interval		8	2.67		6	57.30
Howard 404 time of comparison	15^h	30	0.00	15	45	0.00
Howard 404 time 15^h G.M.T.	15	38	2.67	15	38	2.70
Howard 404 time 15^h G.M.T. (mean)				15^h	38^m	$2^s.68$
Local sidereal time 15^h G.M.T					37	51.75
Correction Howard 404						-10.93

The results of the means of the comparisons before and after the signal differ $0^s.03$. The final result for the error of Howard 404 is only $0^s.01$ from what had been adopted. The experience of the writer before coming to the U. S. Naval Observatory was with comparisons made 10 to 15 minutes before and after the signal. Four comparisons instead of eight, and using a 15-jewel watch, gave a discrepancy between the results before and after the signal usually less than $0^s.1$.

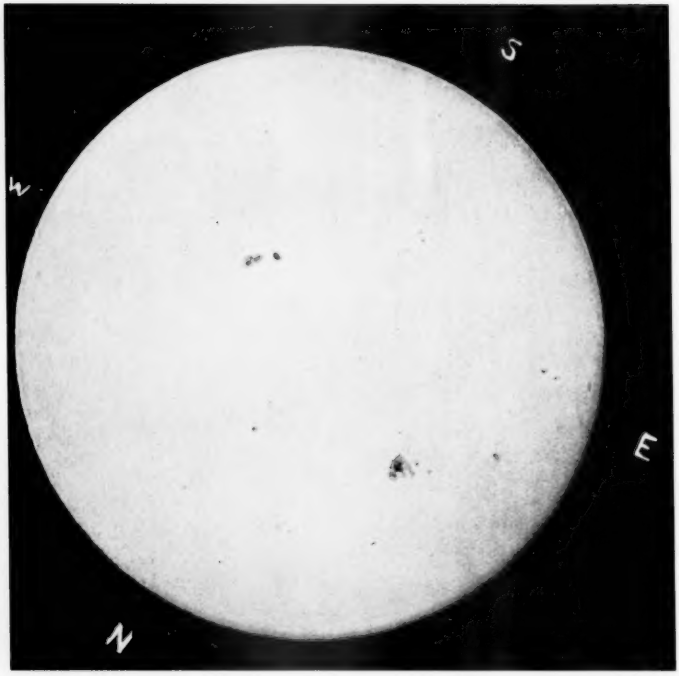
At the U. S. Naval Observatory Eclipse Station, Baker, Oregon, the daily telegraphic time signals were compared by chronograph with the standard chronometer. A half dozen or so times the error of a watch was obtained both by direct comparison with the signal, and by comparison with the chronometer. The two results for the error of the watch never differed by more than $0^s.1$.

These results would seem to indicate that where one can go from his standard timepiece to the telegraph office in 10 or 15 minutes, he can use an ordinary watch for the comparison and feel reasonably sure that the error is at most a little over $0^s.1$.

Setting a Mean Time Clock.

The director of an observatory usually wants his institution known

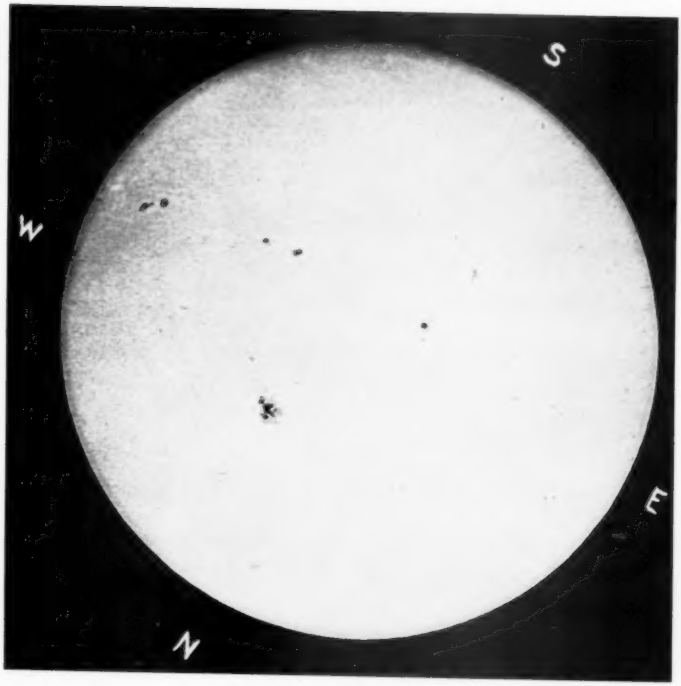
PLATE XXXVIII



THE SUN

Photographed by Latimer J. Wilson with an unsilvered 10-inch Speculum stopped down to 2 inches. June 16, 1919, $0^h\ 30^m$, G.M.T.

PLATE XXXIX



THE SUN

Photographed by Latimer J. Wilson with an unsilvered 10-inch Speculum stopped down to 2 inches. June 19, 1919, $0^h\ 30^m$, G.M.T.

as keeping accurate time, and having the mean time clocks nearly correct will help secure this reputation. Where one of them is a very good clock its error can be kept, say under a second, by receiving an occasional signal. A poorer clock can be set by the good clock as often as desired. Where the observatory has a good clock running on local sidereal time a record can be kept of its rate and correction as deduced from the signals. Between the receipt of signals a mean time clock can be set by the sidereal clock, if desired. An error in the assumed longitude will not affect the accuracy of a mean time clock running on standard time and set by a sidereal timepiece whose correction is based on time signals sent on some hour of standard time.

The setting of a mean time clock by a sidereal whose correction is known is attained by forcing it into coincidence with the sidereal, with proper face reading and at the proper time. If the setting is done at about the same hour each day, for example at the hour of the signal, the reduction can be standardized and the work reduced to almost the simplicity of setting the clock in coincidence with a clock running on correct mean time. The simplification was explained in P. A. **26**, 23, so will be given but briefly here.

Let us take the comparing and setting of the mean time clock Seth Thomas 100, on 1917 November 18. It was compared with Howard Sidereal 404 shortly before 75th meridian mean noon, or 5^h G.M.T.

Mean time interval	$+5^h$	0^m	$0^s.00$
Table III (Ephemeris)	+0	0	49.28
Longitude Washington	−5	8	15.78
Reduction to local sidereal time of 5^h G.M.T.	−0	7	26.50

We take the Greenwich sidereal time of mean noon from the Ephemeris for November 18, considering seconds only,

Greenwich sidereal time of mean noon	$49^s.87$
Reduction to local sidereal time of 5^h G.M.T.	−26.50
Local sidereal time of 75th meridian mean noon	23.37
Correction Howard 404	−58.70
Howard 404 time of 75th meridian mean noon	22.07

We now look at the first column of Table III and find its decimal is .07 at $0^m\ 26^s$, $6^m\ 31^s$, $12^m\ 36^s$, etc. At those intervals before noon a clock running on correct 75th meridian mean time would be in coincidence with Howard Sidereal 404. The next coincidence is $6^m\ 31^s$ before noon. For 7^m Table III shows $1^s.15$. Subtracting from the Howard 404 time of 75th meridian mean noon we have $20^s.92$, or, at 7^m before noon the zero of the Seth Thomas should fall at about 21^s by the Howard clock. We, therefore, wait till that time, 53^m face reading by the Seth Thomas, and watch the Howard sidereal. We count "zero, one, two, three," etc., calling 21^s by the Howard clock zero. Carrying the count by the tick of the sidereal clock we look at the face of the Seth Thomas mean time clock. It is about a second fast. Taking hold of the

pendulum the clock is held back about a second and set swinging approximately in coincidence with the sidereal, by which the count is carried. Releasing the pendulum swinging at about the proper amplitude, we glance up at the face of the Seth Thomas and make sure that the reading of the second hand agrees with the count. This having been checked, attention is again turned to the pendulum, and it is left swinging at the correct amplitude with the beat in as exact coincidence as possible at about the count of 29^s. This is the computed time for coincidence, $23^h\ 53^m\ 29^s$, face reading being $6^m\ 31^s$ before noon.

This is really quite simple when one becomes familiar with the process. The reduction, ($-26^s.50$ for Washington) is carried in the memory and the local sidereal time of 5^h G.M.T., or 75th meridian mean noon, is found for any day by mentally subtracting this from the Ephemeris quantity. Applying the clock correction we have the sidereal clock time of 75th meridian mean noon. A glance at Table III gives the mean time of the next coincidence, and at the same time the reading of the sidereal clock on the zero of the proceeding mean time minute (21^s in the example.) The probable error of a single careful setting, as described in the example, has been determined as $0^s.015$. Ordinarily this accuracy is not necessary, and it is sufficient to take out the time of coincidence to the nearest minute. The mean time clock is then set to the proper face reading in approximate coincidence, and that ends the setting. This rough setting amounts to considering the sidereal a mean time clock which is a certain number of seconds fast, (21^s in the example).

Accuracy of the Signals.

In conclusion, to give an idea of the error which may be expected in a time signal, let us examine the records of the 75th meridian mean noon time signals for the past month, February 1919. Each signal is recorded on the chronograph with the standard clock so that its error may be accurately determined. We find the error in setting the transmitting clock is almost negligible, those errors being 2 of $0^s.02$, 21 of $0^s.01$ and 5 of $0^s.00$. Due to erroneously forecasting the rate of the standard clock there are, however, larger errors, the maximum being $0^s.08$. For accurate work the wireless signals should be used in preference to the telegraphic. To the signals from the three wireless stations operated by the transmitting clock of this observatory the corrections for lag have been determined as follows: Arlington $+0^s.02$, Great Lakes $+0^s.10$, and Key West $+0^s.28$. The results for the Great Lakes and Key West stations have been obtained by applying to the lag of Arlington, Mr. Frank D. Urie's determination of the lag of those stations with respect to Arlington.

U. S. Naval Observatory,
Washington, D. C.,
1919 March 31.

PLATE XL

FIG. 1. THE TRIFID NEBULA IN SAGITTARIUS.
Photographed at the Mt. Wilson Observatory.

WHAT ARE THE NEBULAE?

RUSSELL SULLIVAN.

As we cast our eyes towards the skies on a clear night we see a few thousand stars apparently scattered at random over the dark vault of the heavens. We little realize that among these stars are thousands of nebulae (or little clouds of light), for the most part invisible to the unaided eye and in many cases beyond the reach of all but the most powerful telescopes.

Modern astronomers divide the nebulae into three classes—extended, planetary and spiral. The first class is well shown by Fig. 1, N. G. C. 6514 (New General Catalogue No. 6514). The whole mass is very likely at a high temperature and probably seething with internal movements, although some authorities think that the light is due to a kind of electrical action, similar to the effects observed in comets. The spectrograph has shown that these objects are composed of helium, hydrogen and nebulium—the latter element unknown on the earth. Hydrogen tends to separate from the other elements and occupy the outlying portions of the extended nebulae. Among such objects are to be seen dark nebulae, i. e., dark or faintly luminous markings which obscure the light of the stars or nebulae behind them. The dark lanes in the photograph are thought to be non-luminous portions of the nebula or opaque masses which lie between us and the nebula and cut off its light. The region of the Milky Way is crowded with bright and dark nebulae often merging insensibly into one another. The constitution of the latter is not positively known. Slipher has shown that in one case it is fairly certain that a large, bright nebula, closely allied to a dark object, is not gaseous, i. e., it is probably a cloud of cosmic dust. In this connection it is interesting to note that he has found a few nebulae whose spectra indicate that they are shining by the reflected light of the brilliant stars in their midst. The extended nebulae, whether bright or dark, act as a veil and absorb the light of the faint stars behind them; some of the dark nebulae cover large areas of the sky—others are small and curiously formed. Barnard's observations show that these obscure objects are not confined to the Milky Way, but may be found in other parts of the sky, away from a luminous background and silhouetted against space itself, which glows with an extremely feeble light. The latter conclusion is most remarkable and cannot be explained by any facts known to modern science. The bright extended nebulae have small average velocities of 6 miles per second, and remain in or near the Milky Way. Their actual size is such that a

ray of light would travel many years in crossing from one side to the other. A light-year is the distance that a ray of light (moving at a speed of 186,000 miles per second) travels in one year. The nearest star is about 4 light years from the earth and at this great distance we have hardly begun to sound the depths of the universe. It is generally thought that helium stars (of early spectral type) are formed in these great, irregular masses and the spectrograph has demonstrated the existence of helium stars in the center of the Orion nebula. Reddish stars (of late spectral type) are never associated with the nebulae. About 150 extended nebulae (bright and dark) are known. These objects are members of our own stellar system, but are very remote and lie at an average distance of 2,500 light-years.

The planetary nebulae (so called because they look like the disc of a planet) belong to the second class. High-powered instruments usually disclose a ball and ring structure similar to the planet Saturn. The spectrograph in Campbell's hands has taught us a great many things about these strange objects. They are ellipsoidal shells of shining gases, probably at very high temperature, and similar in composition to the bright extended nebulae. Passing from the nucleus out towards the ring, we find concentric shells of helium, nebulium and hydrogen, in the order named, suggesting the arrangement of gases in the bright irregular nebulae described above. Campbell and Moore have detected a moderate degree of rotation in these objects, amounting to a few miles per second about an axis at right angles to the plane of the ring, the speed of rotation decreasing as the distance from the center increases. The planetary nebulae are moving through space at average speeds of 24 miles per second. Campbell has suggested that they are the wrecks of ancient collisions among the stars, but may form in the future solar systems similar to our own. They occupy a volume of space many times the size of our solar system and, like the extended nebulae, cling closely to the Milky Way or its neighborhood. Each one in its heart holds a star of a spectral type (Wolf-Rayet) still earlier than the helium stars in the Orion nebula. From time to time novae (new stars) have blazed forth in the Milky Way. Shortly after the outburst the majority have become planetary nebulae and finally have assumed the Wolf-Rayet spectrum. Plaskett has recently found the lines of a planetary nebula in the spectrum of Nova Aquilae which made its brilliant appearance in the Milky Way June 8, 1918. Barnard has observed Nova Aquilae in its decline and has actually seen it change into a planetary nebula with a disc of measurable size. These objects belong to our own stellar universe and lie at an average distance of 1,000 light-years. They are comparatively scarce—only 150 have been catalogued to date. Fig. 2 shows N. G. C. 3242, a bright and well-known example of this class.

We now come to the largest and most mysterious class of objects—the spiral nebulae—of which there are several hundred thousand in the

PLATE XLI

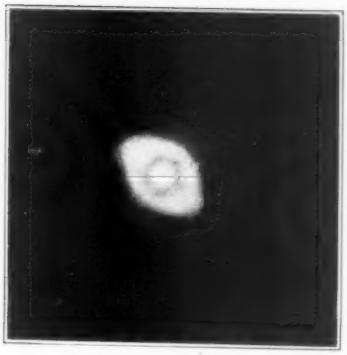


FIG. 2. PLANETARY NEBULA N.G.C.3242 IN HYDRA.
Photographed at the Yerkes Observatory.

PLATE XLII

FIG. 3. SPIRAL NEBULA N.G.C. 5457 IN URSA MAJOR.
Photographed at the Mt. Wilson Observatory.

sky. Recent researches conducted by Slipher indicate that they are moving at the tremendous average speed of 240 miles per second. They are not, as a rule, seen near the Milky Way, probably because they lie beyond it and are eclipsed by the dark nebulae; but if we turn our backs to the Milky Way we will be rewarded by finding immense numbers of them. A spiral nebula is flat and may be compared to a pin-wheel or watch-spring—the latter has only one arm, while a spiral nebula usually has two arms joining the center at opposite points. Fig. 3, N. G. C. 5457, shows the diametrically opposite arms with numerous branches. Van Maanen has recently found that this nebula is rotating rapidly about its center. The speed of a particle half way between the center and the edge is in the neighborhood of 200 miles per second, but the nebula is so stupendous that the particle would take 85,000 years to make a complete rotation. Spectrographic observations by Slipher and Pease on other objects confirm the high rotational velocities of the spiral nebulae. H. D. Curtis has recently estimated that the spirals lie at the appalling distance of one million light-years, and this is a minimum estimate. More likely they are from ten million to one hundred million light-years from the earth. The spectrograph shows that they are not gaseous, but are composed of stars, star-clusters, and even bright and dark nebulae. The latter appear as dark bands on photographs of spirals seen edgewise, and suggest the dark nebulae of the Milky Way. Within the last two years many faint novae have been found in the spiral nebulae, thus proving that the spirals and the Milky Way share this phenomenon in common. In the great spiral of Andromeda a new star appears, on the average, every few weeks. These objects are thought to be distant universes or remote Milky Ways, thousands of light-years in diameter, and similar to our own Milky Way, which also shows evidence of spiral structure.

It is now realized that when we use the word *nebula* we mean one of three things, and if we apply it to one class of objects we must logically refrain from using it in regard to the others—so different are these three classes. Thus modern science has taught us to look upon the sky, not as a meager collection of a few thousand stars, but as a universe teeming with vast nebulous clouds, rings and balls, and gigantic pin-wheels.

THE TIME RELATIONS OF ASTRONOMY AND GEOLOGY.

W. H. PICKERING.

In the following article which, on account of our very limited knowledge of what actually happened in the remote past, must necessarily be somewhat speculative, an endeavour has been made to connect these two sciences as closely as the facts now at our disposal will permit. We have tried to do this in such a manner that as many hitherto unexplained facts as possible shall be explained, while at the same time making no new assumptions that have not already been proposed in order to account for other phenomena. The subject itself is of considerable interest, and it has therefore seemed worth while to endeavor to collect in one place all the most important facts bearing upon it. The unit of time that we shall employ is one million years. Reference will occasionally be made to the work of Professor Chamberlin, the data in such cases being taken mainly from his paper on "The Former Rates of the Earth's Rotation and their Bearings on its Deformation," extracted from Pub. **107** of the Carnegie Institution of Washington.

The sciences of Astronomy and Geology touch at many points, but nowhere more closely than in relation to the question of the origin of our Moon. Sir George H. Darwin, as is well known, showed by a mathematical analysis that has never been successfully confuted, that not only was the Moon formerly much nearer to the Earth, which is obvious from the necessary action of the tides, but also that it must have been within a few thousand miles of our surface at a period of not less than 54 million years ago. He thought that the period of revolution of the Moon in its orbit was then between two and four hours, instead of thirty days as at present, and that the rotation of the Earth on its axis was for a time identical with the revolution of the Moon, so that the latter constantly remained fixed over one point of the Earth's surface. There are difficulties in the way of this view as we shall presently see. He further supposed that the Moon was actually thrown off from the Earth's side by centrifugal force, after the manner in which spectroscopic binaries are supposed to be formed.

According to Professor Slichter, quoted by Professor Chamberlin, p. 47, it appears that in order that the centrifugal force at the equator should balance the force of gravity at the surface, the period of rotation must have been less than 3.82 hours. This high speed as compared to that of the outer planets, which are not appreciably exposed to tidal

forces, is indeed but little, if any, higher than that which we might naturally expect. They rotate in general in about ten hours. We can imagine that a meteorite, if it revolved at all, would do so in the course of a few minutes, or seconds. The few asteroids whose periods have hitherto been determined rotate in periods of from three to ten hours. Apparently the only inexplicably long period of rotation in the solar system is that of the planet Mars.

A planet of the size and mass of the Earth revolving with such a speed would however no longer retain the form of an oblate spheroid, like the Earth at the present time, but would become first a prolate spheroid like one of Jupiter's satellites, rotating end over end, and then, if the speed increased, a pear-shaped body,—with the result that the centrifugal force would very greatly increase. As we know, Darwin believed that, owing to contraction by cooling, this increase actually took place, and the planet thus gradually reached a state of unstable equilibrium, then took on a form somewhat like a dumbbell, and then, owing to the action of the solar tides, it finally separated in two, the larger part forming our present Earth, and the smaller part the Moon. He did not compute a maximum limit to the time at which this event occurred, but suggested that it might have been as much as 200 million years ago.

When he published his investigations, it was believed that the age of the Earth was only a few million years, and the chief criticism upon them was that insufficient time had lapsed for the Moon to have reached its present distance. Moulton also questioned the possibility of a direct evolution of the Moon from the side of the Earth. (Pub. **107** of the Carnegie Institution of Washington, above mentioned, pages 77 to 133.) From all the data now at our disposal, it would seem to be necessary to modify somewhat Darwin's original hypothesis, in such a manner that the escaping material should first have formed a ring about our Earth similar to that of the planet Saturn. After many ages had elapsed, as will appear later, this ring broke in pieces, and formed our present satellite, but the satellite as such and the planet could never have revolved in the same period of time, since their distance would in that case have brought the satellite within Roche's limit.

With the discovery of radioactivity some twenty years ago, investigations were conducted by Boltwood, Strutt, and others on the evidence of its action in the early rocks. Very surprising results were obtained, so much that geologists at first refused to credit them. A very interesting paper by Shapley has recently appeared (Pub. Astr. Soc. Pac. 1918, **30**, 283), in which he quotes Holmes, Barrell, and other geologists as now accepting these results. It appears that analysis of granites of Precambrian age from Norway, Texas, Quebec, and East Africa all agree in assigning to them an age which approximates to 1,120 million years.

This is far more remote than the earliest period assigned by Darwin for the birth of the Moon, and a difficulty which now arises is that more time appears to have elapsed since that event occurred than it at present seems possible to admit. Darwin believed that the combined planet at the time of separation was partly solid, partly liquid, and partly gaseous. He does not state, however, what he believed the liquid to be, whether it was melted slag, and the gases hot metallic vapors, or whether it was simply water, as at the present time. He thought that by a slow process of contraction the bulk of the planet would be so reduced as to give it the necessary additional speed, so that under the influence of the solar tides it might have flown apart. Now if the solid crust of the Earth is over 1,000 million years old, there could have been no such tremendous condensation and contraction of bulk only 200 million years ago as would have been sufficient to have produced the event described. With a thick granite crust, even the oceans must have been liquid at that time, not gaseous.

Two alternatives present themselves, either (*a*) to assume that Darwin's computations and estimates are at fault, and that the separation occurred much more than 1,000 million years ago, when the contraction of the gaseous and liquid rock was greater, or (*b*) to assume them to be correct, and that something different from contraction caused the separation. Whatever it was, we must remember that the action of the solar tides is constantly to reduce the speed of rotation. If the cooling mass under the first alternative, was composed in large part of solidifying rock and metals, the contraction would have been considerable, but the prolonged action of the solar tides would also have had considerable influence on the viscous liquid in reducing the speed, and thus preventing the separation from taking place. If, on the other hand, the tides were merely oceanic, their effect would have been far less, but the contraction would have been insignificant, and insufficient to produce the required result. In neither supposition under case (*a*) therefore does it appear likely that contraction of the crust was instrumental in causing the separation to take place.

Whatever the cause of separation may have been under case (*b*), it is clear that not only must the speed of rotation have been high as compared to that of the present day, but it must also have been very nearly of the right amount to throw off the Moon. Indeed the accuracy of the adjustment must have been extremely close, in order that some very slight event should have been sufficient to produce the computed result. It would now appear that practically the only serious difficulty in accepting the partition of the planet is to find a cause sufficiently powerful to start the separation.

Professor Chamberlin in his well known planetesimal theory of the universe, expresses the view that the origin of our planets was due to the former near approach of our Sun to a star. Such an approach could well have been the cause of the separation of our Moon from the

Earth had the star come near enough, but let us see first what is the likelihood that a star of the mass of our Sun should approach within let us say one astronomical unit, or 93,000,000 miles, of us, in the course of one thousand million years. The average distance apart of the stars in our vicinity, even including those that are much smaller and much fainter than our Sun, and counting doubles and triples as single objects, is about 10 light years. Let us assume them to be moving in all directions with an average speed equal to that of our Sun, or what is nearly the same thing, let us assume them all to be stationary, and our Sun moving through them at its present speed of one light year, or 63,000 astronomical units, in 15,000 years. Then once in every 150,000 years a fresh star will come within 10x63,000 units of us, and another star will pass away. At present there are two stars within this distance. According to these assumptions it is likely that one star will pass within unit distance of us once every fifty thousand millions of millions of years, that is, $150{,}000 \times 630{,}000^2 \cos 30°$.

This direct computation, however, is based on the assumption that the stars are moving in straight lines at uniform speed, and exert no appreciable attraction on one another. The Sun's attraction on the known stars is extremely small. Eddington points out that on α Centauri it exerts an attraction capable in the course of a year of imparting to it a velocity of one centimeter (two-fifths of an inch) in an hour. Otherwise expressed it would take 360 million years to produce a velocity of one kilometer (five-eights of a mile) per second. He also states that "if a small star were proceeding with about average velocity and in such a direction that if undisturbed by the Sun's attraction it would have passed it at a distance equal to that of the planet Neptune, the result of the close approach would be to change the star's course only 5°." (Report of the British Association, Portsmouth 1911.) We can readily see, however, that the effect on stars passing much nearer us would be very considerable. But even if it increased the probability one thousand times, a star would still be likely to pass within unit's distance of us only once in 50,000,000 million years, to express the interval in our adopted unit. The chance that this would have occurred in 1,000 million years is therefore only one in 50,000. The likelihood of an event of this character having occurred is therefore practically negligible. The same argument, it appears to me, would render improbable Professor Chamberlin's theory of the origin of our Moon by capture.

In Popular Astronomy 1919, **26**, 602, we called in the aid of bodies that we designated as planetoids, bodies a few hundred or a thousand miles in diameter, in order to produce the phenomena exibited by a nova. These bodies were supposed to come in swarms, like star clusters or meteors, and to be chiefly found near the outskirts of our sidereal system, where the novas usually occur. According to this hypothesis these bodies were supposed to be extremely numerous, a thousand million going to make a single giant star of type M or N.

Suppose now that some thousand million years ago, or more, when our Sun was travelling in that region of the stellar system, we encountered one of these swarms.

Fortunately for us, our Sun must have passed through it that time unscathed, but suppose that one of these planetoids passed comparatively near to our rapidly revolving Earth. No collision would have been necessary, but the desired external tidal force would have been furnished, and the planetoid would then have shot out of our system. According to Dr. See it would perhaps have been captured, and would thus have formed our Moon, but it does not seem probable that our little Earth could possibly capture anything save a meteor, that was moving with a stellar velocity. The encounter would have been practically instantaneous, and then there would have been no time to lengthen the period of rotation of the Earth. Possibly, however, a series of oscillations and escape of material might have been set up, that would have lasted for some time. Darwin suggests that the Moon might originally have been a chain of meteorites, but reaches no conclusion in the matter.

As a result of this encounter, a considerable quantity of material would have been discharged, some going out into planetary space and revolving about the Sun, and some revolving in individual orbits around the Earth, forming a more or less regular ring something like that of Saturn. Many more pieces after describing independent orbits, constantly perturbed by the Sun and the ring, must have returned to our Earth. In those days stones must very frequently have fallen from heaven. Indeed after a thousand million years or so they still occasionally fall. On the average three stones a year are seen to drop from the skies, and are recovered. Very many more are never found. Farrington computes that about 900 fall every year.

The question at once arises is it possible that the metoric stones falling at the present day can be in any way associated with the great cataclysm which Darwin assumed to have occurred when the Moon was created? It should be clearly understood that such meteoric stones, or aerolites as they are sometimes called, are in no way related to the meteoric irons with which we are more or less familiar. These latter are found to move in cometary orbits, and are unquestionably related to, indeed must be disassociated parts of the comets themselves. Enormous numbers of them have been discovered upon the American continent, but they are very rarely actually seen to strike the Earth.

If the stony meteorites which reach us today once formed a portion of the great ring, much of whose contents later condensed to form our Moon, we should expect to find their specific gravities nearly identical. The mean specific gravity of 77 stony meteorites according to Merrill is 3.51 (Amer. Jour. Science 1909, **27**, 473). The value for the Moon is 3.44,—a difference of but 2 per cent.

That the stony meteorites, on the other hand, were formerly a very common phenomenon is shown by the fact that their remains are fre-

quently found in the abysmal depths of the sea, where little or no subsequent sedimentation has been possible. Some 29 terrestrial chemical elements have been recognized in them, 10 being non-metallic, but none have been found which are unknown on the Earth. Of the eight elements occurring most frequently, six are those most often found in the Earth's crust, the other two being nickel and sulphur. Of the twenty-one minerals hitherto recognized, fourteen have been found in our volcanic products. Two objections are usually raised to the suggestion that stony meteorites are of terrestrial origin. One is that ninety per cent of them contain small crystalline spherical bodies called chondrules, bodies never found in the terrestrial crust. They are supposed to be due to a rapid crystallization in a suddenly cooled mass. Such bodies obviously could not be formed in the interior of the Earth, where sudden cooling would be impossible. The other objection is that quartz, one of the commonest minerals on the Earth's surface is never found in meteorites. Quartz is apparently produced by the action of carbon dioxide on silicates, converting them into carbonates, and freeing the silica. Since meteorites do not possess atmospheres, this action clearly could not have taken place upon them. Nevertheless small quantities of carbon dioxide, and also of hydrogen, have been found enclosed in cavities in meteorites, under a pressure exceeding that of our atmosphere (Farrington, Popular Science Monthly, 1901, **58**, 429). This fact, taken together with their crystalline, often conglomerate, and sometimes even veined structure, is now generally admitted to prove them to be but fragments of a once much larger original body. Their irregular shapes also suggest the same idea. The existence of veins implies fractures attended by subsequent filling.

We must now, however, turn to astronomy for further enlightenment as to their origin. On page 203 of this volume will be found an article dealing with the orbits of aerolites, and showing that a considerable proportion of them at least are revolving about the Sun in orbits smaller than that of the Earth. These cannot therefore be derived either from comets or asteroids. The speed with which they move renders the supposition that they were expelled from terrestrial or lunar volcanoes impossible, and had they been expelled from the Sun they would, unless sufficiently perturbed, have necessarily returned to that body. Moreover it is impossible that veined meteoric stones could exist in the Sun on account of its temperature.

The only remaining possibility is that these meteorites actually represent a portion of the material expelled from the Earth at the time of the birth of the Moon. It is true that their mean velocity about the Sun is somewhat higher than that of the Earth, but it must also be remembered that the latter, as we have seen, was then rotating on its axis in a period of a little less than four hours. It is travelling at present at a rate of 18.5 miles per second. Admitting a rotation as rapid as four hours, the speed of the aerolites should range between 17 and 20 miles.

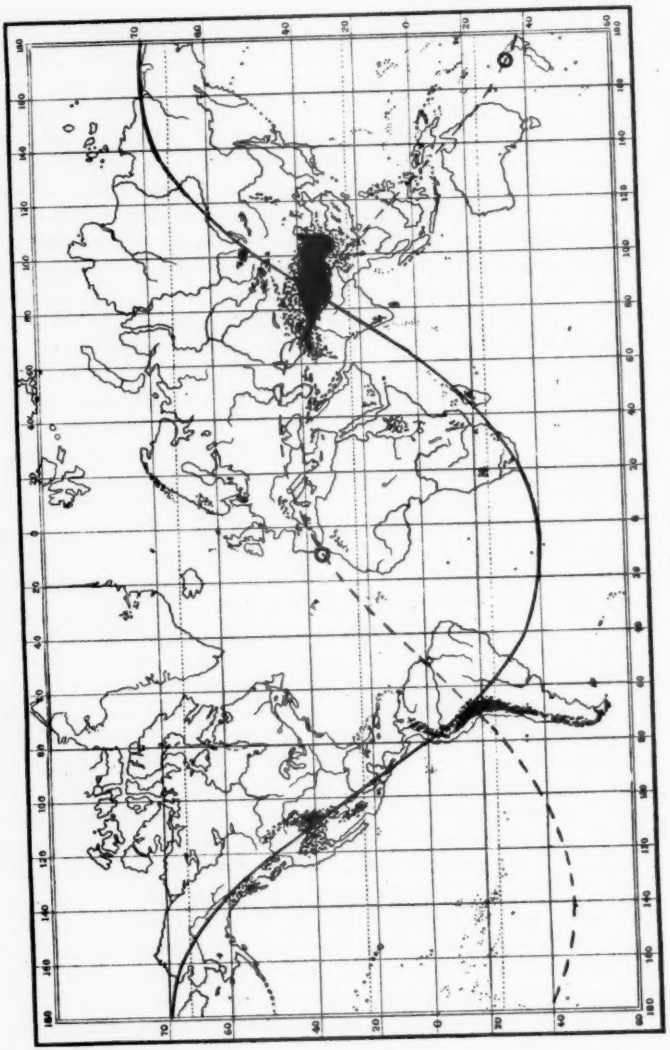


FIGURE 1.

Darwin's hypothesis thus gives what is apparently the only possible explanation of the orbits of the aerolites, as we know them, and their mere existence corroborates his suggestion of the origin of the Moon.

If the birth of the Moon is due to an encounter with a planetoid, that is to say, an approach within one to ten million miles, then it might have occurred on any day since our planet was created, either within the thousand million years since the Precambrian granites were solidified, or before then. Indeed there may have been many ineffective planetoidal encounters. It does not seem possible, however, that such a terrible event as the creation of the Moon from the Earth's side could have occurred since life appeared upon our planet, which must have been soon after the formation of the granites. If our Earth at the time had a solid crust, as Chamberlin thinks probable (p. 47), then it is most likely that the Moon came from the bed of the Pacific, centered about where northern New Zealand is located today, indeed there is no other place from which it could have come (Fisher, Nature, 1882, **25**, 243). A more detailed examination of this question will be found in the American Journal of Geology, 1907, **15**, 23, Harper's Monthly 1907, **115**, 120, and the Scottish Geographical Magazine, Oct. 1907.

It is perhaps a matter of interest to note, that if we describe a circle with the northern point of New Zealand as a center, and a radius of 105°, it will pass through, or near, nearly all the more elevated portions of the Earth's surface. On the chart, Figure 1, all the extended areas which attain an altitude of 10,000 feet above sea level are shaded. Those exceeding 15,000 feet are blackened. The circle above mentioned is represented on this chart by the continuous curved line. The point diametrically opposite to New Zealand lies just off the Strait of Gibraltar. The curve crosses wide stretches of ocean in only two places, the South Atlantic and the Indian Ocean. In the latter case numerous islands occur along its course, in the former there are only a few. It must be remembered that north of latitude + 60°, owing to the distortion of the projection employed, all areas are represented of more than four times the size that similar areas would possess at the equator. Therefore the extended northern level regions, if represented on a globe, would be very greatly reduced in size, and be about opposite to the South Atlantic.

Another curious point is that if we pass a great circle through the Himalayas and New Zealand, it would also cross the plateau of the Andes. This circle is represented on the figure by the dotted line. It divides the land areas of the globe into practically equal parts. It passes among all the larger islands of the East Indies, and near most of the elevated regions remote from the other curve. The two great terrestrial plateaus lie at the intersection of the two curves.

In Chamberlin's paper above quoted, an important objection is proposed to Darwin's hypothesis of the birth of the Moon, that if the Earth changed the rate of its rotation from 3.82 to 24 hours, thereby

changing its shape, that then the equator would be reduced in length 1131 miles, while the meridional circumferences would be increased 495 miles. The equatorial and polar axes must then formerly have been 8286 and 7185 miles respectively, and their ratio 0.867. These changes he states should be visible now in the Earth's crust. In my papers on the Place of Origin of the Moon, above mentioned, it is shown that three-quarters of the Earth's solid crust must have been torn away, and that the remainder, the present continents, consisting of four or five main pieces, floated on the layer of molten rock beneath it, like cakes of ice on water. In order to make up the bulk of the Moon, the layer carried away must have been 36 miles in thickness, and its specific gravity must have been equal to that of the Moon, 3.4. Since the remaining continental area floated three miles higher than the liquid surface which later formed the sea bottoms, the specific gravity of the latter must have been 3.7. The center of gravity of our Earth does not coincide with its center of figure, but lies three miles nearer the level of the floor of the Pacific than it does to the continental levels of Europe and Africa. This shows that the ocean floors are heavier than the continental surface, and where the material of the floor has been forced up above sea level as in Hawaii, its specific gravity is found to reach the phenomenal density of 3.7, or exactly what was computed on the assumption that three-quarters of the former continental surface had been carried away to form the Moon.

It is believed that this material was removed by centrifugal force some 1,200 million years ago or more, and formed as previously stated a ring about our planet like that of Saturn. After over 1,000 million years it broke up to form a satellite, located at a distance of at least 11,000 miles from the Earth's center, as will be presently explained. In the mean time the ocean floors had not only solidified and been covered by our present oceans, but they had thickened to an appreciable depth of several miles. Until the satellite was formed but little change occurred in the length of the terrestrial day, but it now rapidly lengthened until after one or two hundred million years the present period of twenty-four hours was reached.

While we have mountain ranges near the eastern coasts of South America and Africa, which are confined mainly to tropical regions, and may be due to the equatorial compression described by Chamberlin, it seems likely that the main equatorial compression and meridional expansion expended itself over the thin rocky floors of the oceans. Rock under severe pressure is known to act rigidly to stresses of short period, but like a fluid to those of long. Certainly 50 to 200 million years is long enough to allow the thin ocean bottoms to act like a viscous liquid, and adjust themselves to the long continued pressure and tension, thickened slightly perhaps in the equatorial regions, and solidifying towards the poles where it had become thin. This would be particularly true if during the earlier portion of this period, when the displace-

ments were most pronounced, the lower layers of the lithosphere were hot enough to be correctly described as fluid, in spite of the great pressure upon them.

Let us suppose now that the Earth was formerly rotating as a retrograde body, that owing to an encounter with a planetoid, it threw off a stream of rocky masses that ultimately formed a more or less regular ring around it, and that in the slow process of the annual tides, inducing polar inversion, the planet and this ring gradually turned over into the position that Uranus now occupies, with their common axis in the plane of the ecliptic. In this position, as we have seen in POPULAR ASTRONOMY 1919, **27**, 246, a ring is more likely to break in pieces and become concentrated into a satellite. Since this ring revolved so rapidly, the process would have been likely to be a rather slow one. See Stratton's paper on Polar Inversion, in Monthly Notices, 1906, **66**, 401, in which he concludes on mathematical grounds, not only that polar inversion "remains a tenable hypothesis," but also "that the time involved in the scheme is not so great as to invalidate the ordinary dynamical equations."

Let us now see if we can locate the time of this transformation geologically. Under a uniform ring no tides would be formed, but when the ring broke up and formed a huge satellite, only a few thousand miles from the Earth's surface, tides of a most terrific character would have arisen, tides whose height must have been so enormous that they would have deluged all continental areas not well elevated above sea-level. Under Roche's limit a large satellite could not exist at less than 11,000 miles from the Earth's center. Since the tide raising force is inversely as the cube of the distance, at that distance it would have been 10,000 times as powerful as at present. A stationary tidal wave would now be about two feet high if our Moon could be stopped in its orbit. Hence if it were brought to within 11,000 miles of our center we should have a tide four miles in height. In practice this would be greatly modified by the depth of the oceans, the rate of advance of the tide, the surface friction, and the fact that the Moon is not likely to have come together in one piece until it had receded much farther away from the Earth. But even if the tide in those days only reached in extreme cases one-half a mile in height, instead of sixty feet as at present, it is clear that many of the earlier formed geological strata would have been washed away, making breaks in the series, that large inland seas would have been formed, and kept constantly filled by successive high tides, and that certainly some clearly marked and intelligible geological record of the event would have been left, if it ever really occurred. Indeed, according to every possible astronomical explanation of the origin of our Moon, excepting that of very recent capture, the tides must formerly have been much higher than they are at present. The only question is as to when the Moon with is accompanying high tides first appeared on the scene. Still another phenomenon that we should ex-

pect to have occurred at this same time would be that, owing to internal stress, volcanic activity would have been greatly increased in both intensity and extent.

Turning now to the geological record, we find according to the Encyclopaedia Britannica, eleventh edition, under Cretaceous Period "there is a very general unconformity and break between the Lower and Upper Cretaceous." "Throughout the Upper Cretaceous period the marine invasion continued." It extended over the central plateau of France, the Spanish peninsula, over the Alpine region, through Russia into Asia, northern and eastern Africa. "The Cretaceous seas were probably comparatively shallow." "In North America the sea spread over the entire length of the Rocky Mountain region; and in Brazil, eastern Asia and Western Australia, Upper Cretaceous deposits are found resting on much older rocks. Indeed at this time there happened one of the greatest changes in the distribution of land and water that have been recorded in geological history." Towards the end of the period while Europe and much of Asia were quiescent, great volcanic activity developed both in North and South America. It is in the lava flows of India however, that "we find eruptions on a scale more vast than any that have been recorded either before or since. These outpourings of lava cover 200,000 square miles, and are from 4,000 to 6,000 feet thick." This huge lava flow and a similar one that occurred in the nearly opposite longitude, in our north-western states, seem to be very like those that produced the great maria on the Moon. Doubtless the cause was the same, tremendous tidal forces, acting on a fluid interior, causing a fracture of the crust. The area of the Indian eruption was about equal to that of Mare Serenitatis and Tranquilitatis combined.

These high tides producing powerful inter-island currents would have greatly favored the transportation of the early species both of plants and animals between such regions as Asia and Australia, an advantage which later species do not now possess. This would explain the singularly undeveloped fauna of Australia at the time that it was discovered, the absence of the cat tribe rendering life there for other animals comparatively pleasant and easy, and development very slow.

In Shapley's paper above cited appears a table giving the ages of the different geological periods, derived he tells us from the work of Professor Barrell of Yale University. The precise dates are doubtless uncertain, but the extreme antiquity of these periods Shapley states is now accepted by a number of prominent geologists. The numerical values appear to be based primarily on the age of the Precambrian rocks as determined by their radio activity. According to Shapley's table the middle of the Cretaceous Period lay between 75 and 90 million years ago. These figures fall well within Darwin's limits of 54 and 200 million years for the birth of the Moon.

We have assumed above that the ring did not break in pieces to

form our satellite until after the time when its plane of rotation was perpendicular to the plane of the Earth's orbit, and had therefore become direct. Under such conditions, while the mean temperature of the Earth would have been the same as at present, if the solar radiation were the same, yet the heat must have been much more uniformly distributed, the tropics would have been colder, and the polar regions warmer. We can readily see that while the polar nights were six months long, just as at present, and must have been very cold, yet the summers would have been very much warmer under a nearly vertical Sun. The snow caps must have been greatly reduced in size, and continuous clouds, and perhaps rain, would have given the summers a moist fairly uniform climate analogous in some respects to that of a greenhouse. Many forms of life, both animal and vegetable, can withstand periods of protracted and extreme cold, provided they have alternating with them short periods of warmth, in which to propagate. Thus we find not only mosquitoes, but also yellow poppies and other arctic wild flowers growing in Greenland today, although the temperature there sometimes goes down to seventy degrees below zero Fahrenheit in the winter time.

The fact of the former existence of a temperate climate in the polar regions has hitherto been difficult to explain. In Spitzbergen for instance within 11° of the pole, workable seams of coal in the form of lignite have been found, and others are known in Iceland, Greenland, and in the Antarctic Continent. The Spitzbergen coal fields give evidence of a distinctly temperate climate, supporting birches, large oaks, magnolias, cypresses, ivy, and a thick undergrowth, together with fruits, and a profuse insect life. They continued in existence from the Cretaceous down to the Miocene period, or from 80 until about 20 or 30 million years ago. During the whole of this time the Earth's equator must have been strongly inclined to the ecliptic, if our explanation of the high polar temperature is correct. It could only have been after the Moon got far enough away from the Earth to leave its equatorial orbit and approach the plane of the ecliptic, that the monthly tides began to give their powerful aid in effecting the polar inversion of our planet, and reducing the inclination of the equator to its present comparatively small figure of 23°.5. Darwin in his computations assumed that at the time of the birth of the Moon the inclination was only 11°, according to which the polar regions would have received much less sunlight even than they do today. A high polar temperature under these conditions would certainly be difficult of explanation, unless other portions of the Earth's surface were unbearably hot.

As we have seen the rotation of our ring of meteoric material must have already become direct in the Cretaceous Period, when it broke in pieces, and the great tides began to be formed, otherwise our Moon would have had a retrograde revolution in its orbit today. In the periods extending to 100 million years back of the Cretaceous, the in-

clination of the equator to the ecliptic must therefore also have been very high, and throughout this time the polar regions should have experienced a temperate climate. Unfortunately the rocks of these periods in Greenland, Iceland, and Spitzbergen have generally been destroyed, but a small area of Jurassic rocks of this early date in Spitzbergen are coal bearing. While a temperate climate seems to have existed throughout the whole polar basin until as late as within 20 or 30 million years ago, after that it turned cold, and has remained so ever since. There is one very extraordinary exception to this statement however. In the Lyakhov Islands north of Siberia, in latitude 73°, Baron Toll tells us that he found Post-Tertiary deposits of comparatively recent date containing the bones of the mammoth, rhinoceros, horse, and tiger, and relics of a forest vegetation, thus implying a mean annual temperature of some 40° higher than at the present time. The observation seems to be strictly local however, nothing analogous having been found anywhere else at so late a period.

What a difference of 40° in the mean annual temperature implies, may be seen, if we consider that a drop of 5° to 10° would bring the glaciers back into our White Mountains, and a fall of 20° would give all of our northern states a climate colder than that of Iceland, and bury all their great cities beneath a sheet of glacial ice. If the temperature that a body would possess in interstellar space is that of absolute zero, 460° Fahrenheit below that of melting ice, and if we owe our added 520° entirely to solar activity, it is little wonder that ice ages have been a rather frequent experience of our little planet in the past thousand million years. There seems to be, to say the least of it, no very adequate ground for demanding that our Sun should have given an absolutely constant output of heat, throughout a period extending through over 1,000 million years.

Moreover we know that at the present time the output varies slightly, about five per cent, from week to week, according to Abbot (POPULAR ASTRONOMY, 1918, **26** 633). The period is very irregular, however, often exceeding two weeks. The variation seems to be clearly followed, according to Clayton (Smithsonian Miscellaneous Collections, 1917, **68**, No. 3), by slight changes of temperature at the Earth's surface. A permanent drop of ten per cent should produce a general fall of 13° in the Earth's mean annual temperature, and would thus in the course of a few years make a very serious difference to us. We have not the space to go into the matter further here, nor into the question of the effect of volcanic haze on mean annual temperature (Abbot and Fowle, Smithsonian Miscellaneous Collections, **60**, No. 29).

We have just seen that when the Earth's axis lay in the plane of the ecliptic, not only should the polar regions have been unusually warm, but the equatorial regions must have been unusually cold. They had of course no long polar night, but they would have had two short sharp winters every year. During one of these they also would have suffered

from the shadow of the ring. As a result we should expect to find evidences of ice action extending nearer to the equator than either before or since that day. It so happened that one of our various ice ages fell in the Permian period, about two hundred million years ago, and we find according to Chamberlin (Fundamental Problems of Geology, p. 181), "Apparently at no other period of geological history were the phenomena of glaciation and aridity so extraordinarily manifested." Glaciation in India extended across the tropic of Cancer into the torrid zone, in the latitude of Calcutta. It reached across the tropic of Capricorn from the south in both Australia and South Africa. Indeed Chamberlin remarks that the phenomena furnish "the supreme test of all atmospheric and climatic doctrines."

Another fact that has always been difficult to explain in our early geological history is to render a reasonable account of the origin and method of development of the flying vertebrate creation,—the flying reptiles and birds. The forearms of these creatures are of such very specialized structure, so ill-adapted to moving either through the water, or over the ground, or even dropping from the limbs of trees, that it is hard to see how by any of the well recognized principles of evolution, depending on the survival of the fittest, they could slowly have continued through the early ages to have become gradually more and more specialized, until they suddenly achieved the great advantage of being able to fly. It seems more probable indeed that their development was accomplished through some earlier undiscovered form, related to the flying fishes, the many boned pectoral fins gradually evolving into true wings, as in the case of cetaceans they have developed into flippers.

The difficulty of understanding their development is not entirely eliminated, but it is certainly greatly diminished, if we believe that formerly the force of gravitation was very much less in intensity than it is today. We can well believe that for many millions of years after the Moon was hurled away from the side of the Earth, the centrifugal force throughout the torrid, and what are now portions of the temperate zones, very nearly balanced the force of gravity. There would indeed have been no efficient cause to reduce the speed of rotation of the Earth until the Moon developed from our equatorial ring. For hundreds of millions of years therefore, accepting the geological tables as correct, the force of gravity in the equatorial and temperate regions of the Earth's surface must have been slight compared to its present amount.

The pterodactyls or flying lizards developed early among the terrestrial animals. Their earliest remains are found in the lower Jurassic, long before the Cretaceous period, going back some 175 millions of years. The very earliest forms doubtless developed near the equator, where flying was easiest, and then traveled north and south where it became more and more difficult. Their wings were of much the same shape and proportion as those of a bat, but perhaps a little narrower,

giving therefore rather less supporting surface. If however we compare pictures of the skeletons of these two animals which have approximately the same wing spread, we shall see at once that the body of the reptile was very much the larger of the two, and would if it were now living have been much the heavier.

Those birds having the greatest spread of wing at the present day, such as the condor and albatross, usually stretch to about nine and twelve feet respectively, although larger figures are occasionally claimed. During the Cretaceous period the flying lizards attained a spread of eighteen, and sometimes even of twenty-five feet, and must have been of considerable weight, but soon afterwards became extinct. It is extremely doubtful if such large animals could fly at all at the present day, and any reasonable increase in density of the atmosphere that we might assume could have been of little assistance to them.

It seems plausible that of the large flightless birds now living, and of recent times, such as the ostrich and rhea of Africa and South America, the dodo of Mauritius, the aepyornis of Madagascar, the cassowary of the East Indies, the emu of Australia, and the moa of New Zealand, all had ancestors which once were able to fly, but later abandoned the art, finding it too difficult. It will be noted that everyone of these birds save the last, which may have migrated, dwelt within the torrid zone, or within easy reach of it.

On the other hand the auk and the penguin, two much smaller flightless birds, extremely similar to one another in both structure and appearance, although living at the opposite poles, are utterly unlike the group above mentioned. Flight would certainly be a great advantage to them, as it is to other sea-birds, and if they had once flown we cannot imagine that they would ever have abandoned the practice. The fact that they are natives of the polar regions supplies the explanation, for at no period of the Earth's history was the force of gravity less there than it is at present, and in early times it was much greater, so that their ancestors could never have learned to fly. Their wings accordingly developed merely as flippers.

When we come to those huge reptiles, the dinosaurs of early times, we find the tendency to exceptional size even more marked than among the flying creatures. If we imagine two animals of similar shape, but one being of twice the length of the other, we shall find the larger to be somewhat the less agile. Compare for instance a large dog with a small one. The reason is obvious. An animal's strength is proportional to the cross section of its muscles, and the larger animal is therefore four times as strong as the smaller one, but eight times as heavy. If we consider the agility to be proportional to the muscular strength divided by the weight, then doubling the size halves the agility. For this reason an elephant is less agile than a mouse. As a practical experiment animals larger than an elephant are not a success at the present day. There is plenty of food for them, in Africa for instance, but they would not

be sufficiently agile, and would be too easily fatigued. Therefore they do not exist. If the force of gravity were reduced ten times, a man could leap into the air thirty feet without hurting himself, and an elephant could bound over low shrubs and bushes. His mass would of course remain the same, so he could not dodge or turn corners any better than at present, and he would therefore need his stout legs, but he could travel much faster and farther without becoming too tired.

The largest African elephants reach a height of nearly twelve feet, and a length of perhaps sixteen. Their progenitors are only found in the later geological periods, and there is no evidence that even the mammoth was any larger than a modern elephant, although more impressive on account of its huge tusks. When we go back to the Cretaceous period however, the age of reptiles, terrestrial animals such as the atlantosaurus and brontosaurus reached a length of over eighty feet. A considerable proportion of this was neck and tail, but if we assume that the creature weighed ten times as much as one of our largest elephants, we shall probably not be overstating, but perhaps understating its weight. If gravity was at that time one tenth as great as at present, we can see at once that these creatures would be perfectly practicable as living machines, and be by no means crushed by their own weight. Indeed they may have been rather swift of foot.

From whatever point of view we look at it therefore, astronomical or geological, the evidence points to the fact that the Earth revolved on its axis more swiftly in those early days than at present, and that its axis was more inclined. The geological evidence points to the Cretaceous period as the one when the great floods produced by the first lunar tides began to manifest themselves, and the greatest volcanic eruptions to occur, and this we therefore believe was the time when the Earth's equatorial ring broke in pieces and formed our Moon. The geologists say that this occurred from 75 to 90 millions of years ago. Darwin computed that the lunar tides began to affect our speed of rotation at not less than 54 million years in the past, and suggests that it might have been perhaps as much as 200 million. We thus reach mutually confirmatory results from both sides of the investigation.

It will be well to summarize here the sequence of astronomical events which are supposed to have taken place according to this article. More than 1,200 million years ago the Earth possessed a solid crust, and was revolving on its axis in a retrograde direction in a period of a little less than four hours. It was then in a portion of our stellar system where planetoids were numerous, and one of them passed sufficiently near it to cause it to part with three-quarters of its surface crust. The material that escaped formed a ring about the Earth resembling that of Saturn, and at about the same relative distance from the planet. The ratio of the polar and equatorial axes of Jupiter is 0.941; of Saturn it is 0.907. That for the Earth, at that early date, we found to be 0.867. Owing to the action of the annual tide, caused by our Sun, the planet

slowly inverted its axis, until this lay nearly or quite in the plane of the ecliptic. This was between 100 and 200 millions of years ago, and the ring was then broken by solar perturbations, and gradually coalesced to form a satellite at a distance of at least 11,000 miles from the Earth's center. This satellite revolved in a positive direction in the plane of the former ring, producing enormous oceanic tides. Owing to the tides which it produced on and particularly within the Earth, the period of the latter and the distance of the satellite both increased. As the satellite retired farther and farther from the Earth, the solar attraction caused the plane of its orbit to approach that of the ecliptic. It then produced a powerful monthly tide, which acting in conjunction with the solar annual tide, continued the inversion of the terrestrial poles until they arrived at their present inclination.

Before closing, we will now pause a moment to look at the case from the reverse direction. The warm polar regions of the recent past lead us to believe that the Earth's axis in comparatively recent times was but slightly inclined to the ecliptic. At its present distance the monthly tides created by the Moon could not possibly have produced the change to the present inclination that we now possess. The Moon must therefore within some 20 or 30 million years, as Darwin stated, have been much nearer the Earth, and revolving somewhat in its present plane.

Since the change of inclination prior to this for perhaps 200 million years was extremely slow, although with a small inclination of the Earth's axis to the ecliptic this change should be particularly rapid, it appears that the plane of the Moon's orbit must then have nearly coincided with our equator, which could only have occurred if the Moon was very near to us. In that case only the solar annual tides would have been efficient, and their action towards inversion necessarily slow.

If the Moon as a spherical mass had been very near us for those 200 million years, its tidal action in retarding the Earth's rotation would have been very marked, and the length of the day, and the surface gravity, not very different at that period from what they are at present. Yet this was the time when the largest flying creatures ever created flew, and the largest quadrupeds walked. The Moon therefore could not then have existed as a sphere, but rather as a ring, consequently producing no tides and no retardation. The great inland seas and tremendous volcanic outbursts succeeding this period mark the change from a ring to a sphere.

The existence of the ring implies an outburst from the planet, or some similar catastrophe, which would have destroyed all life upon it, but since low forms of life have existed for about 1,000 million years, the outburst must have occurred before that time. Computation shows that the near approach of a star within even that period is extremely improbable, but planetoids in the regions where novas appear must be comparatively numerous if they are the cause of these phenomena, since novas are of frequent occurrence in those regions. The near ap-

proach of a planetoid under the conditions stated could, and probably did, cause the formation of the ring.

The peculiar shapes of our continents and oceans, unlike anything that we find on either Mercury, Mars, or the Moon, together with the measured density of the material forced up from the floor of the Pacific, confirms the view that the substance now forming the Moon took its origin from the side of the Earth. The occasional fall of aerolites further confirms this position. Their internal structure shows that they formerly formed part of a much larger body, and their computed orbits indicate that they can have come from none other than our own Earth or Moon. This series of suggestions is therefore now offered to explain the observed facts.

Mandeville, Jamaica, March 24, 1919.

TWENTY-THIRD MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The twenty-third meeting of the Society was held on Tuesday to Friday, September 2-5, 1919, at the University of Michigan, Ann Arbor. The scientific sessions were held in the auditoriums of Natural Science Hall and of the Physics Laboratory, but the members had ample opportunity to visit the Detroit Observatory, the members of the staff of which have held such a high place in American astronomy, beginning with Brünnow, then Watson, and followed by the long line of astronomers who have studied at this institution. Under the present director, Professor Hussey, the observatory has been considerably enlarged, the most notable addition being the 37-inch reflecting telescope.

An innovation in the meetings of the Society was the opportunity to join forces with two other gatherings held during the same week, that of the American Mathematical Society, and of the Mathematical Association of America, which had been determined for Ann Arbor at the same time. Members of all three societies were housed at the Newberry Residence Hall and at the Michigan Union, and the arrangement demonstrated once more the ideal condition of meetings where members live close together for several days. Because of the unsettled conditions following the war, there was in advance considerable uncertainty as to the attendance at the meeting, but in spite of the long railroad journeys involved there were about seventy members and guests present at the astronomical meeting.

In opening the first session, Acting President Schlesinger referred to the great loss which the Society had suffered since the last meeting in the death of Professor Edward C. Pickering, who had been president

of the Society for thirteen years, and had been the leading figure at its meetings throughout that time. The Society had also lost Professor Charles L. Doolittle, who had acted as treasurer from the founding of the Society in 1899 until he retired in 1912. The following resolution, which had been passed by the Council, was endorsed as representing the sentiment of the members of the Society and was ordered to be printed in the publications.

> The Council of the American Astronomical Society records with regret the death on February 3, 1919, of
>
> EDWARD CHARLES PICKERING
>
> who had been President of the Society since December 30, 1905. His success in introducing new methods into the observatory, particularly with regard to the determination of the brightness and the spectra of stars, his extraordinary ability in carrying out large projects, and the extent and diversity of his experience and knowledge, have given him a permanent place among the great names in the history of science. The Society will keenly feel the loss of his presence at its meetings. The members of the Society had every reason to regard him as a warm friend, and to them the sense of personal loss is very deep.

On Tuesday evening the astronomers, mathematicians and friends were the guests of Professor and Mrs. Hussey at an informal reception at the observatory, where in addition to the usual attraction of such a function there was opportunity to inspect the astronomical equipment, and to see the telescopes in operation.

On Wednesday the Society was once more the guest of Professor and Mrs. Hussey at luncheon. At this time the members sat for the annual group photograph, and there were also pictorial reunions of former members of the staffs of the Detroit, Yerkes, and Lick Observatories. On Wednesday evening the masculine members joined in with a smoker with the mathematicians at the University Club, while the ladies were entertained at the home of Professor Joseph L. Markley.

On Thursday afternoon there was a joint meeting of the three societies with the following program.

> "Mathematics and Statistics."—Retiring Address of the President of the Mathematical Association of America. Professor E. V. Huntington, Harvard University.
>
> "The Work of the National Research Council with reference to Mathematics and Astronomy."—Professor Ernest W. Brown, Yale University.
>
> "Reports on the International Conference of Scientists at Brussels."—Dr. Frank Schlesinger, Allegheny Observatory, Dr. L. A. Bauer, Carnegie Institution.

This was followed in the evening by a joint dinner of the astronomers, mathematicians, and friends at the Michigan Union, where emphasis was laid on the human side of astronomy and mathematics. In

the after dinner toasts it was interesting to note how much humor could be found in these seemingly abstract sciences.

Because of the tendency to congestion of the program of astronomical papers, the rule had been announced that one contributor should present in turn but one paper, until everybody had had a chance. As a result it was possible to have complete and full discussion of each paper, and the program was carried through without the haste which has sometimes characterized the sessions.

The Council took the following action in regard to dues:

> Voted that members who have served in military service of the allied powers for more than one year shall have their dues to the Society remitted during the term of such service.

The most important item of business during the meeting was the adoption of the proposed amendments to the Constitution, in regard to election of officers and organization of the Council. The amendments were adopted in the form in which they had been distributed to the members with the exception of a single verbal change. In the second sentence of paragraph 5, article III, the words "and who have not previously held the office of president" were omitted, being considered unnecessary in view of the next sentence which limits the president to a single term.

Article III to read as follows:

ARTICLE III. OFFICERS AND COUNCIL

1. The officers of the Society shall consist of a president, two vice presidents, a secretary, and a treasurer, who in addition to the duties specifically assigned to them by this Constitution shall discharge the other duties usually incident to their respective offices.

2. The Council shall consist of the officers, the ex-presidents, and six other members of the Society. The management of all affairs of the Society not otherwise provided for shall be entrusted to the Council. The president and the secretary of the Society shall serve respectively as chairman and secretary of the Council. Each officer of the Society shall be responsible to the Council and shall administer his office in accordance with its instructions.

3. The Council shall enact such By-Laws as may be found needful and proper for administering the affairs of the Society, and may from time to time modify or repeal such By-Laws.

4. The officers and members of the Council shall be elected by ballot at the annual meeting. The president shall appoint a nominating committee of three members of the Society who shall prepare an official ballot. On approval of the ballot by the Council it shall be sent to each member at least one month prior to the annual meeting and such ballots if returned to the secretary in envelopes bearing the names of the voters shall be counted at the annual meeting. Every such ballot shall contain a name proposed by the nominating committee for each vacancy, with blank spaces in which the voter may substitute other names. A majority of all votes cast in person or by mail shall be necessary to election. In case of failure to secure a majority for any office, the members present at the annual meeting shall choose by bal-

lot between the two having the highest number of votes, or, in the case of councilors, amongst the five having the highest number of votes.

5. The term of office shall be three years for the president, two years for the vice presidents, one year for the secretary, one year for the treasurer, and three years for each of the six other members of the Council. Those members who have completed their terms as vice presidents at or before the time of election shall be eligible for election as president. The president shall not be eligible for re-election. The vice presidents and the six other members of the Council shall not be eligible for re-election at the meeting in which their terms of office expire.

6. If the president of the Society die or resign before the expiration of his term of office, the Council may designate one of the vice presidents to serve as acting president until the next annual meeting, when a president shall be elected by the Society. Vacancies which may exist at any time in the offices of secretary or treasurer may be filled temporarily by the Council. If a vice president or an elected member of the Council die or resign more than one year before the expiration of his term, the vacancy for the unexpired term shall be filled by the Society at the next annual meeting.

Article VI to read:

ARTICLE VI—AMENDMENTS

This Constitution shall not be amended unless notice of the proposed amendment be sent by mail to every member of the Society at least one month in advance of the meeting at which such amendment is to be considered; and such amendment in order to be adopted must receive three-fourths of the votes cast in person and by mail.

TEMPORARY PROVISIONS DATED JULY 1, 1919

Of the vice presidents elected at the annual meeting in 1919, one shall serve for two years and the other for one year. The secretary elected in 1918 shall complete his term of three years before his office becomes vacant. At the annual meeting in 1919 two members of the Council shall be elected to serve for three years, and two for two years.

On the basis of the new arrangement, the nominating committee consisting of Messrs. Brown, Eichelberger, and Miller presented the nominations, which were endorsed by the Council, and on the last day the officers were elected by the Society.

President, 1919-22	Frank Schlesinger
Vice President, 1919-20	George C. Comstock
Vice President, 1919-21	Walter S. Adams
Treasurer, 1919-20	Benjamin Boss
Councilors, 1919-21	Solon I. Bailey
	W. J. Hussey
Councilors, 1919-22	Henry Norris Russell
	V. M. Slipher

Officers continuing to serve unexpired terms are:

Secretary, 1918-21	Joel Stebbins
Councilors, 1918-20	Ernest W. Brown
	Otto Klotz

The Council elected new members of the Society as follows:

William E. Anderson, Miami University, Oxford, Ohio.
Bernhard H. Dawson, Observatorio Astronomico, La Plata, Argentina.
J. P. Henderson, Dominion Observatory, Ottawa, Canada.
H. M. Jeffers, University of California, Berkeley, Cal.
Guy Lowell, 12 West Street, Boston, Mass.
John Paraskevopoulos, Yerkes Observatory, Williams Bay, Wis.
Max Peterson, University of Wisconsin, Madison, Wis.
Russell W. Porter, Springfield, Vermont.
Myrtle L. Richmond, Mt. Wilson Observatory, Pasadena, Cal.
W. Carl Rufus, University of Michigan, Ann Arbor, Mich.
Shinzo Shinjo, Imperial University, Kyoto, Japan.
Paul Sollenberger, U. S. Naval Observatory, Washington, D. C.
Coral Wolfe, Mt. Wilson Observatory, Pasadena, Cal.

Members in attendance at the Ann Arbor meeting were:

Sebastian Albrecht
S. I. Bailey
E. E. Barnard
L. A. Bauer
Harriet W. Bigelow
Dorothy W. Block
F. E. Brasch
Ernest W. Brown
Annie J. Cannon
C. A. Chant
W. A. Cogshall
George C. Comstock
Clifford C. Crump
R. H. Curtiss
Ralph E. De Lury
A. E. Douglass
R. S. Dugan
W. S. Eichelberger
Alice H. Farnsworth
E. A. Fath
Edwin B. Frost
Caroline E. Furness
A. Estelle Glancy
F. Henroteau
Louis A. Hopkins
Herbert A. Howe
W. J. Hussey
C. C. Kiess
Otto Klotz
Oliver J. Lee
O. M. Leland
George A. Lindsay
H. C. Lord
A. C. Lunn
W. D. MacMillan
John A. Miller
E. J. Moulton
F. R. Moulton
Jesse Pawling
John Paraskevopoulos
George H. Peters
Max Peterson
Edison Pettit
Hannah Steele Pettit
William F. Rigge
E. D. Roe, Jr.
W. Carl Rufus
Frank Schlesinger
Shinzo Shinjo
Elliott Smith
V. M. Slipher
Paul Sollenberger
Joel Stebbins
John Tatlock
Frank D. Urie
G. Van Biesbroeck
Warren J. Vinton
Worcester R. Warner
Evelyn W. Wickham
Anne Sewell Young

At the occasion of the joint dinner, the following resolution, introduced by Dr. Klotz, was unanimously adopted.

> The American Astronomical Society, the American Mathematical Society, and the Mathematical Association of America desire to express their appreciation to the University of Michigan for its hearty co-operation in the successful carrying out of our meetings and deliberations.
>
> We deeply recognize the hospitality that has been extended to us, which has added so much to the enjoyment of our stay in Ann Arbor.

At the final session the Society voted the following:

> The American Astronomical Society assembled in Ann Arbor for its twenty-third meeting herewith expresses its appreciation of the kind hospitality extended to it by Director W. J. Hussey and Mrs. Hussey, also to Dr. Curtiss and the other members of the staff whose hearty co-operation added materially to the success of the meeting.

The reception on Tuesday evening at the Observatory and the enjoyable luncheon there the following noon emphasized the value of the social element of our gatherings, and to which the success of our annual meeting is in no small measure due.

The Council left the selection of the place and date of the next meeting to the executive committee. Inasmuch as the Society will meet with the American Association for the Advancement of Science in Chicago in December, 1920, it was agreed that the summer meeting of 1920 should be preferably in the East.

ABSTRACTS OF PAPERS.

VARIATIONS OF TYPE IN THE CEPHEID VARIABLES *l* CARINAE AND η AQUILAE AS SHOWN BY THE GENERAL SPECTRUM

By SEBASTIAN ALBRECHT.

About twelve years ago variations in the spectra of three Cepheid variable stars were announced corresponding to changes of spectral type. The measures of three-prism spectrograms of η Aquilae and *l* Carinae, which were in part available at that time and in part secured shortly afterwards, have now been put into final shape for publication. Slides were shown of drawings portraying the variations of wave-length with changing phase of light-variation of the star for numerous individual spectrum lines. The curves of change of wave-length for the same lines in the series of stellar types were also given in the drawings. From the parallelism in trend of the two sets of curves the variations of type of the Cepheids seems quite clearly brought out. These data were treated according to my method for quantitatively determining the spectral type of the star corresponding to each spectrogram, and variations of type were found from F8 to G9 for *l* Carinae, and from F6 to G6 for η Aquilae. These results are based upon the general spectrum, i. e., upon the metallic lines, as distinguished from the hydrogen spectrum.

Recently Adams and Joy found that the variations in the spectra of Cepheids corresponding to changes of spectral type are confined to the hydrogen spectrum, and that the general spectrum does not share in these changes. As these results are in conflict with the variations of type in *l* Carinae and η Aquilae which I obtained from the general spectrum, my data were re-discussed with special reference to their possible explanation by the two following effects in the general spectrum, also referred to by Adams and Joy: (1) a general slight widening of the spectral lines at minimum, and (2) an increase in the intensity of the so-called "enhanced" lines at maximum. My detailed examination shows that nearly all the shifts in wave-length in these Cepheids are

satisfactorily explained by a strengthening or a weakening of the same components of the lines (blends) as in the stellar spectra from the "earlier" to the "later" types, rather than by the widening of the lines at minimum or a strengthening of the enhanced lines at maximum or both.

Thus, for the present at least, it seems impossible to harmonize my results and those of Adams and Joy. It should be noted that my results would bring into accord for Cepheids simultaneous changes of visual light, of photographic light, of radial velocity, of type based on the general spectrum, of type based on the hydrogen spectrum, and of color-index both observed photographically and computed from the changes of type. On the contrary, if the general spectrum does not share in the changes of type shown by the hydrogen spectrum—according to the results of Adams and Joy—then the changes of color-index computed from the general spectrum are practically zero, constituting an apparent outstanding discordance.

A tabulation for a number of Cepheids also showed: (a) a progressive trend of types with increasing length of period (known before), the effect being, however, very much more pronounced for short than for longer periods, and (b) the apparently complete lack of a relation between the range through which the type varies and the period. The type range in the 22 Cepheids listed averages one type-interval—(as F to G)—with only moderate deviations from this mean.

Inasmuch as the surface conditions on Cepheids—i. e., in the comparatively shallow layer in which all of the light that reaches us originates—are undergoing constant and apparently violent changes, it seems probable that a considerable overlapping of the distinguishing characteristics of types takes place. With good modern instrumental equipment, applied especially to the brighter Cepheids, it should be possible to determine approximately the extent to which Cepheid spectra deviate from pure stellar types.

A SYSTEMATIC SEARCH FOR NOVAE AT THE HARVARD OBSERVATORY.

By S. I. Bailey.

New stars have always attracted the keenest interest on the part of astronomers; yet their discovery has nearly always been a matter of chance. It may well be that no nova of recent times sufficiently bright to be a conspicuous object to the naked eye has escaped observation. How many fainter novae have failed to make their presence known is only open to conjecture.

A systematic, photographic search for all novae over the whole Milky Way is now being carried on at the Harvard Observatory. This involves the frequent examination of all stars of the ninth magnitude, and

brighter. The observations are chiefly made by Misses Woods and Mackie. The investigation cannot be carried on with all the promptness and completeness that are desirable. It is hoped, however, that results will be obtained which may lead to a definitive discussion of those novae that at maximum attain a magnitude of 9.0, or brighter.

ON THE CHANGE IN THE PERIOD OF THE VARIABLE STAR BAILEY NO. 33 IN THE CLUSTER M 5.

By E. E. Barnard.

In *A. N.* 4409 the writer intimated that the period of this small variable was probably changing. Observations have been made specially to verify this supposition. Equality of the light of this star with that of a small star close to it, occurs when the variable at its rise to maximum changes most rapidly. This is the best time for observations to determine the period. Such observations have been carried on (visually) since 1899 with respect to the neighboring star, which I have called *k* (See *A. N.* 4409).

The star was observed at the present apparition of the cluster on four dates at the time of equality with *k*. Though these were made under adverse conditions of seeing, I think the result is good. They show that since 1913 the period has shortened, while from 1899 to 1913 the period was lengthening. The change seems to have been rather sudden. Taking as a base the normal from three observations in 1899 I have obtained the following periods.

Interval	No. of periods	Period in days	Period			
		d				
1899-1900	688	0.50147330	12^h	2^m	$7^s.293$	
1899-1903	2750	.50147330			7.293	
1899-1904	3671	.50147314			7.279	
1899-1908	6483	.50147341			7.303	
1899-1911	8792	.50147357			7.316	
1899-1913	10172	.50147368			7.326	
1899-1915	11566	.50147354			7.314	
1899-1916	12284	.50147338			7.300	
1899-1917	12992	.50147329			7.293	
1899-1918	13867	.50147309			7.275	
1899-1919	14559	0.50147310	12	2	7.276	

The precision with which the period may be determined is shown by the values in column 3 where, in every case, there is an exact agreement in the figures to the first six decimals of a day. The last column shows the change in the period.

The times of equality of light with the star *k* can be determined quite closely, under good conditions to a fraction of a minute. My method of observing is to compare the light of No. 33 with *k* repeatedly from the time it is $0^m.2$ or $0^m.3$ less until it is the same amount brighter than

k. The results are then platted and the time of equality derived by stretching a thread along the observations until the best adjustment is had, and then reading the time of intersection with the zero line.

REMEASUREMENT OF HALL'S STARS IN THE PLEIADES.

By E. E. Barnard.

In the years 1886-7 Professor Asaph Hall measured sixty-three small stars in the Pleiades with the 26-inch telescope of the Naval Observatory at Washington. These faint stars were connected with some of the bright stars of the cluster. The measures were printed in *Astronomical Journal* **7**, 73-78, 1887.

After a correspondence with Professor Hall, I took up the remeasurement of these stars visually in 1903 to see if any of them belonged to the cluster, which was Professor Hall's original idea. A comparison of my measures with Hall's showed differences that might be in the nature of a personal equation between the two observers. I therefore decided to wait and remeasure the same stars again as soon as sufficient time had elapsed, so that the results would depend on one observer and one telescope. They were remeasured in 1917 and 1918. The results are in good agreement with Hall's measures in showing that some of the small stars actually belong to the Pleiades while the others belong to the background of the sky and are left behind by the drift of the cluster. A brief statement of the results may be of interest.

Two of the stars were not found at the assigned positions. They were Nos. 37 and 39 which, according to Hall, were compared with Anonyma 25 and 29 respectively. I examined other stars near for them but they were not found. Dr. Trümpler of the Allegheny Observatory, who is investigating the cluster photographically and who has shown that it covers a much larger area than the bright stars would suggest, has found that these two stars are really referred to Anonyma 15 and 24p, the two preceeding stars of the small triangle that precedes Alcyone. The stars Hall Nos. 23, 24, and 25, which were recorded as being observed with Anonyma 14 were not found in the indicated place, but after a search among the other stars, I found that the star of comparison was really Anonyma 17 instead of 14. Thus all of Hall's sixty-three stars are accounted for and remeasured.

It would not be surprising if some of the comparison stars used by Hall do not belong to the Pleiades. The measures show that Anonyma 17 is a stranger with a proper motion of its own toward the south-east. Annual P. M. 0″.055 in P. A. 255°±. This star is Berlin (B) A. G. C. 1169 (8^m0) 1875.0 $3^h\ 39^m\ 56^s$ + 23° 24′ 52″.9.

The star H.32 is probably variable. H.40 was found to be a difficult double;

1907.5 P.A. 77°.1. Dist. 1″.42 14^m— 14^m5 (2 n.)

Its position is:

1918.0 $3^h\ 43^m\ 59^s.58$ $+ 23°\ 35'\ 46''.8$

An inspection of Hall's observations and my own show that perhaps 20 per cent of Hall's stars either certainly or probably belong to the cluster. Some of them are as faint as the 14th magnitude. It is significant that the stars H.34, 35, and 36, which seem to belong to the cluster, were compared with Alcyone.

VARIABLE STARS IN M 11.

By E. E. Barnard.

Two stars, one of which is variable and the other probably so, were found on negatives taken with the 40-inch telescope. Their positions are

Var.	1	1900.0	α	18^h	45^m	$47^s.58$	δ	$-$	$6°$	$15'$ $22''.2$ $(14^m.0)$
"Var."	2	1900.0		18	45	38.27		$-$	6	19 47.7 (13.5)

The variability of No. 1 has been verified at Harvard College Observatory by Professor Bailey. The other awaits verification. They are both probably long period variables with a large range of magnitude. No. 1 certainly has a long period with a range of at least several magnitudes.

ON THE VARNISHING OF ASTRONOMICAL NEGATIVES.

By E. E. Barnard.

It is important that astronomical negatives be varnished to prevent deterioration from atmospheric influences, etc. Negatives made twenty-five years ago which were varnished show, by small portions left uncovered near the edge of the plate, that if not varnished the negative would have suffered from the action of the air upon the gelatine surface. The method of varnishing a negative is explained in the paper which will be printed in Popular Astronomy.

SOME OBSERVATIONS OF THE TOTAL SOLAR ECLIPSE ON MAY 29, 1919, AT CAPE PALMAS, LIBERIA.

By L. A. Bauer.

The author, assisted by Mr. H. F. Johnston, carried out a general program of observational work, mainly geophysical, in connection with the solar eclipse of May 29, 1919, which was total at the station finally selected, namely Cape Palmas, Liberia. Although totality was to last at this station about six and one-half minutes, the astronomers fought

shy of this station in view of its being in the rainy belt. However, for the purposes of the expedition of the Department of Terrestrial Magnetism, it did not matter whether clear conditions would be had or not, since the geophysical effect which was primarily to be investigated, namely the possible effect upon the Earth's magnetic field, would pass through any clouds. However, as it has turned out, for the third time, although astronomers at other places were unfortunate in having the desired clear sky, clear conditions were encountered by my party.

When the author left Washington, it had been arranged that he would occupy, conjointly with Dr. Abbot of the Smithsonian Institution, La Paz, Bolivia, in order that he might simulate there conditions which he encountered at his station Corona, Colorado, the elevation of which is 12,000 feet, during the eclipse of June 8, 1918. As Dr. Abbot intended to look after the photographic work, the author did not provide himself with special photographic appliances for purely astronomical work. However, upon arrival in England, it was found impracticable to reach a South American station in time for the eclipse; accordingly it was decided to proceed to Cape Palmas, Liberia, instead.

The observational program included the following: magnetic and electric observations; meterological observations; shadow-band observations; times of contacts; and photographs such as could be obtained of the solar corona with the appliances on hand. This comprehensive program was carried out successfully, excepting the atmospheric-electric work which, owing to the deterioration of the dry-cell batteries secured in England, had to be abandoned. Fortunately, however, another party of the Department of Terrestrial Magnetism, stationed at Sobral, Brazil, where the British party under Dr. Crommelin was located, carried out a full program of magnetic and electric work.

The slides shown gave a general view of the station and facilities available at Cape Palmas, as also two views taken during totality with a small camera, which showed clearly the remarkable solar prominence of May 29, as well as the pronounced coronal extensions. Owing to the courtesy of Dr. Eddington of Cambridge University, it was likewise possible to show a slide made from an excellent photograph secured by him at his station on the Isle of Principe.

The eclipse of May 29 as seen at Cape Palmas was not nearly as dark, in spite of its long duration, as the one of June 8 of last year, as observed by the author at his mountain station, Corona, Colorado, where the latter eclipse lasted but one and one-half minutes. There was a marked difference in light, both as seen visually and as shown by the photographs, between the inner corona and the outer extensions.

Although three observers took part in the shadow-band observations, at different points, following even greater precautions than were taken at Corona during the eclipse of last year, no shadow bands were observed at Cape Palmas by the various observers, whereas they were clearly observed at Corona.

A definite indication was again had with regard to the small magnetic perturbation or oscillation which, in accordance with previous experience, takes place during the period of a solar eclipse. This magnetic effect, as also the one which may be shown with regard to changes in the electrification of the atmosphere during the eclipse, are of special interest in connection with the wireless-telegraphy experiments conducted during the eclipse at numerous stations along the coasts of Africa, Europe and America, under the direction of Dr. W. Eccles of London. Respecting the latter observations, some interesting results have been received by him indicating that the distance of transmission of signals sent from Ascension Island, in the South Atlantic Ocean, was increased during the time when the eclipse shadow was between the transmitting station and the receiving station.

HYPERSENSITIZING COMMERCIAL PANCHROMATIC PLATES.

By S. M. Burka (Introduced by C. C. Kiess).

Ordinary photographic plates, which owe their sensitivity to the silver halides alone, are sensitive only to the violet and blue regions of the spectrum. If, however, suitable dyestuffs be added, either by the laboratory method of bathing the plates in a solution of the dye, or by the commercial method of incorporating the dye in the emulsion, the plates become sensitive to other regions.

The effect of ammonia on the sensitivity of commercial plates containing dyes was investigated. As a result of numerous trials using varying concentrations of ammonia, the procedure finally adopted was to bathe the plates before exposure for four minutes at 16° to 18°C in a solution of 3 cc ammonia (20% NH_3) in 75 cc water and 25 cc ethyl alcohol and dry as rapidly as possible. They were then exposed in a grating spectrograph and the spectral sensitivity determined. In a number of cases the speed was also determined by a sensitometer of the Chapman Jones type, and by the Hurter and Driffield method.

The sensitivity of orthochromatic (sensitive to green and yellow) plates showed, with one exception, no appreciable change. Every panchromatic (sensitive to all colors) plate tried (nearly a dozen different brands) had its speed increased at least 100% to white light and over 400% to red. The sensitivity was also extended 100 or more angstroms into the red. The strong minimum in sensitivity in the green shown by most plates was to a great extent smoothed out. The most striking increase in sensitivity was shown by a Wratten and Wainwright Panchromatic plate which was used three years after its "expiration" date. The sensitivity was increased over 600% throughout the region from $H\beta$ to beyond $H\alpha$.

The ammoniated plates, however, deteriorate rapidly, showing chemical fog in development, so that most brands are useless four or five

days after treating. The plates should, therefore, be used a day or two after ammoniating and over development avoided. They should also be kept cool. If the plates are used immediately after drying, greater increase in sensitivity can be obtained by omitting the alcohol from the bath and using 3½ cc ammonia to 100 cc of water.

SOME RECENT DEVELOPMENTS IN THE STUDY OF SS CYGNI, 213843.

By LEON CAMPBELL.

This short paper attempts to point out two interesting features which have been recently developed in the discussion of this irregular star. First, a study of the deviations in the observed rise to maximum from the uniform period of 48.8 days reveals a striking similarity in the two maxima of the curve of O—C, and leads us to hope that we may be able to remove at least one unknown quantity in the irregularities of the period.

Second, a comparison of the forms of the four typical light-curves which this star presents shows that no matter what the form of the curve may be when the star is increasing in light, once the star reaches its maximum brightness the fall to minimum is practically the same in any instance. In other words, that the irregularities in the form of light-curve occur when the star is rising to maximum and not after it reaches that point. Five slides were exhibited to illustrate these points.

THE SPECTRA OF VARIABLE STARS OF LONG PERIOD.

By ANNIE J. CANNON.

The spectra of 382 variable stars of long period have recently been studied on 1900 Harvard photographs, for the purpose of general classification. These spectra fall into three classes, M, N, or R. Three hundred and fifty five, or 93 per cent, have spectra of Class M, in all of which, except fifteen, bright hydrogen lines are present at or near maximum. In classifying the spectra having bright lines, two things must be considered, the general type of the spectrum and the superposed bright lines. When we consider only the bright lines, three groups may be formed, according to whether $H\beta$, $H\gamma$, or $H\delta$ is the strongest line. The most interesting group proved to be that in which $H\beta$ is the strongest, for the class of spectrum was there found to be not of any division of Class M, but of a peculiar class, resembling the spectrum of π^1 Gruis, $22^h\ 16^m.6$, $-46°\ 27'$. Magn. 6.65. This spectrum bears some resemblance to Class R and is characterized by broad

bright and dark bands between $H\beta$ and $H\gamma$. A dark band at about 4640A has wide bright bands on each edge. Only fifteen variable stars have yet been found to be of this class, among which may be mentioned R Andromedae, R Lyncis, T Sagittarii, and R Cygni. A slide, showing the resemblance of the general class of spectrum of R Andromedae and π^1 Gruis, was thrown on the screen. The type of spectrum of π^1 Gruis is rare, if not unique, among stars of constant light.

We may subdivide the spectra of Class M into two groups, according to whether $H\gamma$ or $H\delta$ is the strongest emission line. When $H\gamma$ is strongest, the spectrum is usually of an early division of Class M, and sometimes even of Class K5. Changes in the class of spectrum frequently occur during the light variations. A slide was exhibited to show that the spectrum of S Carinae was of Class K5 at maximum, and of Class Mc at minimum. As the star decreases in light, the spectrum becomes very faint in the region of shorter wave-length than $H\gamma$, and at minimum nearly all the light is between $H\beta$ and $H\gamma$.

The line $H\delta$ is, however, the strongest emission line in more than half of these spectra. Examples of this group are the stars U Orionis, R Leonis, and R Hydrae. The spectrum is of the later divison of Class M, and the bands of titanium oxide are strongly marked. $H\delta$ often remains bright, during half of the period. At minimum, the spectrum is faint from $H\beta$ to 4227, and nearly all the light is concentrated in a wide band near $H\delta$. It appears that this group of stars should be redder at maximum, whereas those of the preceding group should be redder at minimum. Observations of color indices for a few cases tend to confirm this fact.

Some of the results of this investigation may be summarized as follows:

1. When the hydrogen lines are bright, the spectrum is of some division of Class M or R. The proportion known at present is 1 of Class R to 24 of Class M.

2. It is the exception rather than the rule for $H\beta$ to be bright when the spectrum is of Class M, and, if bright, it is never the strongest emission line. Likewise, in spectra of Class R, $H\delta$ is never the strongest emission line.

3. Changes occur in the class of spectrum during the light variations, and in the relative intensities of the bright lines. In some cases, $H\delta$ appears first and becomes from ten to twenty times as bright as $H\gamma$. At maximum light, $H\gamma$ often reaches equality with $H\delta$. The relative intensities of these two lines often vary at different maxima of the same star.

4. Changes occur in the distribution of light in the continuous portions of the spectrum.

5. The intensity of certain absorption lines, especially 4227, varies. In several spectra, this line is much stronger at minimum than at maximum. In the spectrum of o Ceti, it varies at different maxima.

It is evident that a large number of these spectra must be studied throughout all portions of their light curves before any accurate classification can be made.

ATMOSPHERIC REFRACTION NEAR THE HORIZON.

By GEORGE C. COMSTOCK.

This paper is the outcome of the author's war work in teaching navigation and it is primarily due to a statement contained in *Bowditch* (official text book of the Navy) to the effect that the refraction at low altitudes is so uncertain that the navigator should avoid observation of bodies within ten degrees of the horizon.

The literature readily available contains scant material for estimating the amount of variation shown by the horizontal refraction after due allowance has been made for the atmosphere temperature and pressure at the observer's positon, but from an excellent series of observations of the times of sunset made at Key West, Fla., and kindly furnished to me by the Hydrographic Office, U. S. Navy, I find for the probable error of a computed refraction, assuming the observations to be faultless, a number lying between $\pm 2'$ and $\pm 3'$. The differences O—C are of a distinctly systematic character, varying with the season of the year and are apparently related to local effects produced by extensive coral reefs covered with shallow water, over which the sun set during a large part of the period covered by the observations.

Although no account of such effects is taken in the refraction tables the differential equation of the refraction shows that they may appreciably influence the amount of the refraction through modifying the vertical temperature gradient in the lower strata of the atmosphere. Also, it is to be borne in mind that the refraction tables are based upon an assumed thermometric gradient for the whole atmosphere and that this assumption is widely different from the average condition of the atmosphere as determined by modern meteorological research, e. g. the stratosphere with its zero gradient and of variable extent is wholly ignored in the ordinary refraction theory.

To examine the combined effect of these influences I have made use of mechanical quadratures to compute directly from the differential expression for the refraction its amounts corresponding to a considerable range of atmospheric conditions, so chosen as to cover approximately the variation of conditions actually found by meteorological exploration of the lower atmosphere. In so far as the results thus obtained relate to moderate zenith distances, e. g. 75°, they may be summarized in the statement that the refractions thus computed differ from the tabular values by amounts that rarely exceed a few hundredths of a second of arc.

At the horizon, however, the conditions are widely different and, for a given temperature and pressure, variations amounting to several minutes of arc may easily result from plausible changes in the distribution of temperature at different levels in the atmosphere.

Illustration of such changes is found in the Key West sunset observations for which I have computed refractions based upon three different assumptions as to the distribution of temperatures in the lowest two kilometers of atmosphere. These hypotheses are:

a. A distribution such as obtains just preceding a thunderstorm, i. e., an overheated stratum of air adjacent to the earth's surface.

b. The average condition indicated by meteorological observations at sub-tropical stations.

c. The conditions that obtain in the early evening over a snowclad earth, (inverted gradient).

With one exception the refractions furnished by the Key West sunset observations fall within the *a* - *c* range of conditions with strong preference for the *a* - *b* region. This result confirms that reached by E. C. Pickering and others that in the mean the refraction suffered by rays from the setting sun is less than the tabular refraction based upon observations of stars.

A theoretical analysis entirely similar to that above sketched was made for refractions corresponding to an altitude of four degrees, with the unexpected result that the large variation of the horizontal refractions within the range of conditions *a* - *c* has almost completely disappeared at 4° altitude. The range of values in the refraction due to varying conditions in the lower two kilometers of the atmosphere is reduced from nine minutes at the horizon to less than one second of arc at 4° altitude.

It appears to follow from these results that the precept officially made to the navigator that he should avoid observations within 10° of the horizon is excessively cautious, and excludes much possible data that ought to be utilized for fixing the position of his ship. This is particularly true in the winter season when even at the horizon the sun is inconveniently far from the prime vertical.

STUDIES OF CLASS B SPECTRA HAVING HYDROGEN EMISSION LINES.

By R. H. Curtiss.

The surveys of spectra for the Henry Draper Catalog furnish material which modifies our ideas with reference to the stars having Class B and Class A spectra with visible hydrogen emission lines.

Previous lists included 110 stars. In the classification of 241,000 spectra for the Henry Draper Catalog a gain of twenty only was made.

But a number with suspected bright Hβ will undoubtedly have Hα emission, increasing the total probably to 200.

The effect of the revision for the new catalog so far as published has been to confine the spectra of these stars to Classes Bo-B8. In the first seven hours of right ascension in the old lists there were thirteen stars of Class A, one of Class A5, and two of Fo. In the Henry Draper Catalog in this region of the sky, no object of this group remains outside of the limits Bo to B8 and only one outside of the limits Bo to B5.

In the region considered the stars of Class Bp are much more numerous relatively among the brighter stars of Class B. Data from the Henry Draper Catalog follow:

Photographic Magnitude	0.0 - 3.9	4.0 - 6.9	7.0 - 9.9
Stars, Bo —B5	34	312	386
Stars, Bo —B5p	6	22	12
Proportion with emission:	1 to 5.7	1 to 14.2	1 to 32.2

Apparently these stars are brighter superficially, more massive, or less dense than "normal" stars of Class B, perhaps all three.

Studies of the disappearance of the bright lines as such in the spectra of Pleione, f^1 Cygni, and Mu Centauri indicate that the emission lines though strong may be a transitory phenomenon.

ON THE ECLIPSING VARIABLES RT PERSEI AND U CEPHEI.

By R. S. Dugan.

Photometric observations, in March 1919, of the primary minimum of RT Persei show a residual from the time calculated by the linear part of the formula in *M. N.* **75**, 692, of O—C = —22 minutes. A rediscussion of all residuals will probably show that the variation of the period has followed a sine curve since the star has been under observation.

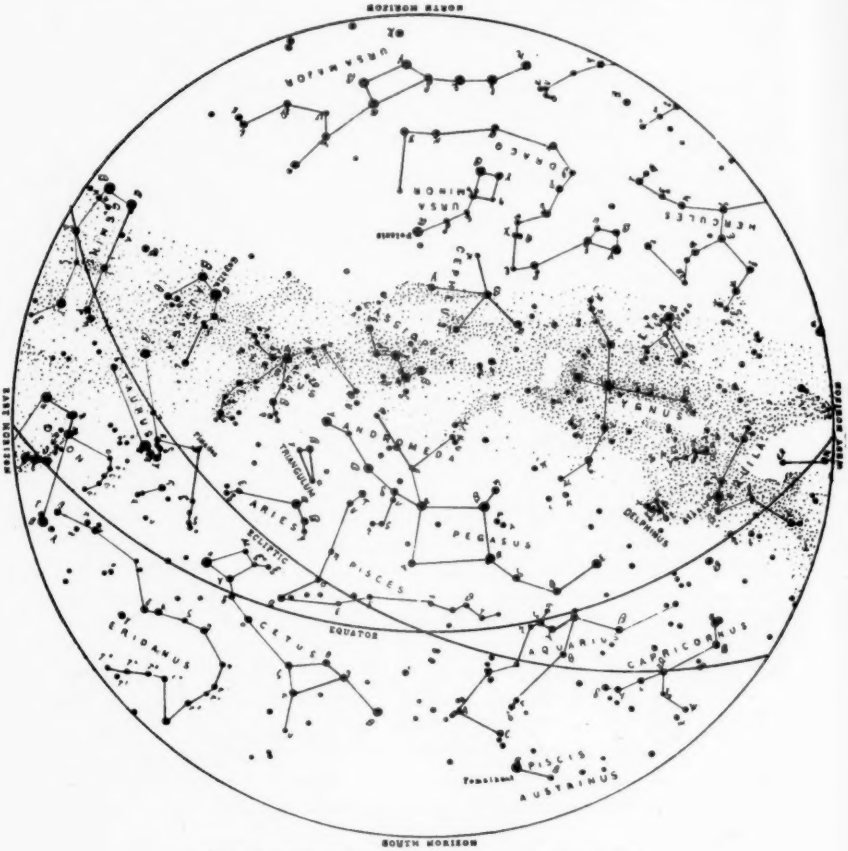
This case illustrates the need of frequent observation of the eclipsing variables, even of those for which the form of the light curve has been accurately determined. At least one primary minimum of each eclipsing variable should be observed each year. The secondary minima should receive much more attention than has been given them, with a view to collecting material for an explanation of the variation of the period.

The deep total eclipse of U Cephei at primary minimum, and the annular eclipse at secondary minimum, furnish a good case for the determination of the degree of darkening toward the limb. The light curve observed by the writer indicates the preliminary result that the intensity at the limb is about six-tenths of the intensity at the center of the disk.

[*To be continued.*]

PLANET NOTES FOR NOVEMBER, 1919.

The *sun* will continue its course southeastwardly during the month and at the end of the month will be 21° 30′ south of the equator, which is almost its greatest southern declination. It will move from Libra into Scorpio, and will end the month a short distance north of the bright star Antares.



THE CONSTELLATIONS AT 9:00 P. M. NOVEMBER 1.

The phases of the *moon* for this month are as follows:

Full Moon	Nov. 7	at	6	P.M.	C.S.T.
Last Quarter	14	"	10	A.M.	"
New Moon	22	"	9	A.M.	"
First Quarter	30	"	11	A.M.	"

Mercury will become visible in the west just after sunset a few days before November 12, on which date it reaches a point of greatest elongation east. It

will be visible a few days after this date also and will then move rapidly toward the sun and again soon be lost in its rays. It will pass between the earth and the sun on December 2. It will be moving nearer to the earth during this period.

Venus will be at a point of greatest elongation west of the sun on November 23. It will then be a brilliant object in the morning sky. On and near this date it will rise between four and five hours before the sun. It will be receding from the earth.

Mars, like Venus, will be in the morning sky during this month. Toward the end of the month it will be approaching the meridian at sunrise. During this period it will be nearly as bright as a first magnitude star and will be increasing in brightness. It will be moving toward the earth.

Jupiter will be in quadrature, 90° west of the sun, on November 10. It will rise before midnight and may be observed earlier from night to night.

Saturn will be about one and one-half hours east of Jupiter during this period, and will therefore not be quite as favorably situated for observation. It will be near quadrature at the end of the month.

Uranus also reaches a position of quadrature on November 20. It will be 90° east of the sun, and will therefore be on the meridian at sunset.

Neptune will be in quadrature, 90° east of the sun, on November 4. It will be near the planet Jupiter in the sky.

Occultations Visible at Washington.

[From the *American Ephemeris.*]

Date 1919	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Nov. 2	44 Aquarii	5.7	8 24	346	8 47	313	0 23
2	51 Aquarii	5.8	12 07	82	13 04	230	0 58
7	124 B Arietis	6.4	5 31	136	5 55	190	0 24
7	53 Arietis	6.0	12 13	68	13 30	264	1 16
8	43 Tauri	5.5	10 40	130	11 24	205	0 45
9	*l* Tauri	5.2	7 49	66	8 41	278	0 52
10	68 Orionis	5.7	8 03	65	8 50	292	0 48
11	162 B Gemin.	5.7	17 32	54	18 14	346	0 42
14	14 Sextantis	6.3	13 33	123	14 38	279	1 06
27	16 B Capricorni	6.2	7 12	19	8 01	293	0 49
27	β Capricorni	3.2	7 17	26	8 11	287	0 54
28	ν Aquarii	4.5	6 47	49	8 01	256	1 15
29	30 Aquarii	5.6	10 06	33	10 58	278	0 52

VARIABLE STARS.

New Variable in Libra.—In *A.N.* 4996 Mr. M. Mündler announces a new variable star in Libra. Its position for 1855.0 is

$$\alpha\ 14^h\ 55^m\ 41^s \qquad \delta\ -10°\ 58'$$

The star is at maximum about magnitude 12.5, and becomes invisible, i. e., much below magnitude 13.3, at minimum.

Minima of Variable Stars of Short Period.

[Calculated by D. C. Kazarinoff at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1919 November							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	1 17							
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	6 10;	14 2;	21 18;	29 11				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	2 1;	9 12;	16 22;	24 8				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	6 6;	13 18;	21 5;	28 7				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6 8;	12 11;	18 13;	25 16				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	5 21;	13 0;	20 3;	27 7				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	3 6;	10 2;	23 20;	30 17				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 7;	14 11;	21 15;	28 20				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 23;	11 18;	20 12;	29 7				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 11;	14 10;	22 9;	30 8				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6				30 19				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	7 1;	12 18;	18 12;	29 23				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	2 23;	9 18;	23 8;	30 3				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	2 18;	10 17;	18 14;	26 12				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	5 7;	13 14;	21 21;	30 5				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	5 17;	13 14;	21 11;	29 9				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8		12 3;	25 7;					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	6 5;	15 16;	25 3;	28 6				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	6 23;	19 9						
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	1 11;	14 19;	21 11;	28 3				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	8 3;	16 8;	24 12;	28 14				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	4 7;	10 8;	22 9;	28 9				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8 17;	17 9;	26 1					
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	8 18;	19 4;	29 14					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	5 18;	13 19;	21 19;	29 19				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	2 16;	8 9;	19 20;	25 14				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	1 15;	12 19;	24 0;	29 15				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	5 3;	13 8;	21 13;	29 18				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	7 11;	15 2;	22 17;	30 8				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	4 8;	16 13;	28 18					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	5 6;	12 10;	19 14;	26 18				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	3 22;	10 18;	17 13;	24 9				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	2 16;	11 23;	21 6;	30 13				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6 14;	13 4;	19 19;	26 10				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	4 15;	13 0;	21 10;	29 20				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	5 15;	12 1;	18 12;	24 22				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	1 12;	8 18;	23 8;	30 14				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	9 2;	17 5;	25 7					
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	2 2;	11 13;	21 1;	30 12				
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	7 1;	13 21;	20 18;	27 14				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	3 1;	9 0;	20 21;	26 19				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6 16;	13 10;	20 4;	26 22				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	1 13;	8 33;	16 9;	23 19				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	4 4;	10 18;	17 9;	30 14				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	5 4;	14 0;	22 19					
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	7 11;	14 18;	22 2;	29 10				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7 20;	14 15;	21 10;	28 5				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	1 22;	9 10;	16 22;	24 10				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	1 8;	10 22;	20 12;	30 3				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	4 12;	11 22;	19 9;	26 19				
133926 Hydrae	13 39.0	−26 23	8.6—12.7	2 21.5	4 10;	16 0;	21 19;	27 14				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	2 20;	9 20;	16 19;	30 18				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1919 November
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	1 15; 8 13; 15 10; 22 8
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	2 22; 11 8; 19 18; 28 4
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	1 3; 8 19; 16 11; 24 3
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	2 11; 9 19; 17 3; 24 11
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	2 23; 11 5; 19 11; 27 17
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	1 18; 10 15; 19 11; 28 8
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	10 17; 20 9
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	7 16; 14 11; 21 7; 28 2
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	9 2; 17 11; 25 20
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 0; 18 8; 24 11; 30 15
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	6 6; 13 11; 20 16; 27 21
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	1 11; 8 20; 23 14; 30 23
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	3 15; 11 19; 20 0; 28 4
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	1 2; 8 15; 16 3; 23 16
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	7 23; 15 16; 23 10
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	2 17; 10 16; 18 16; 26 16
WX Sagittae	53.6	—17 24	9.2—10.8	2 03.1	1 13; 10 2; 18 14; 27 3
WY Sagittae	17 54.9	—23 1	9.5—10.6	4 16.0	10 2; 19 11; 28 19
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	2 15; 7 19; 18 3; 28 11
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	4 19; 12 1; 19 7; 26 13
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	6 11; 13 8; 20 6; 27 4
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	9 9; 24 12
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4 1; 11 5; 18 9; 25 12
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	4 18; 11 21; 19 0; 26 3
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	5 9; 13 17; 22 0; 30 7
RR Draconis	40.8	+62 34	9.3—13	2 19.9	4 0; 12 12; 21 0; 29 11
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	4 4; 10 19; 17 11; 30 17
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	13 19; 26 17
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	8 12; 16 4; 23 19
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	6 10; 14 0; 21 14; 29 3
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	3 0; 10 4; 17 9; 24 14
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	8 19; 17 18; 22 6; 26 17
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	5 22; 12 17; 19 11; 26 5
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	1 19; 9 4; 16 13; 23 22
TT Lyrae	24.3	+ 41 30	9.4—11.6	5 05.8	2 19; 13 7; 18 13; 23 18
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	6 19; 13 7; 19 20; 26 8
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	3 21; 9 21; 15 21; 27 21
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	3 10; 16 17; 23 8; 29 23
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	9 22; 19 2; 28 5
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	3 17; 12 3; 20 14; 29 0
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	6 3; 12 21; 19 16; 26 11
UW Cygni	19.6	+42 55	10.5—13	3 10.8	1 11; 8 8; 15 6; 22 4
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	5 20
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	1 3; 10 18; 20 9; 29 23
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 4; 19 9; 27 14
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	1 22; 9 10; 16 22; 24 9
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 13; 9 4; 16 18; 24 8
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	4 2; 14 4; 24 7
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	7 9; 14 19; 22 4; 29 13
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	2 20; 12 13; 22 5
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	3 4; 11 1; 18 22; 26 19
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 3; 12 7; 22 10
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	23 7
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	8 6; 13 10; 18 15; 23 19
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	4 8; 12 16; 20 23; 29 6
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	5 3; 12 16; 20 4; 27 17
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	1 21; 10 3; 18 9; 26 14

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1919. November							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7								
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	3 8;	11 12;	19 15;	27 18				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 15;	14 8;	22 2;	29 20				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	9 2;	23 22;						
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	3 19;	11 18;	19 17;	27 15				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 1;	9 20;	17 15;	25 10				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	8 20;	16 3;	23 9;	30 16				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		10 0;	26 0					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	1 6;	9 20;	18 10;	27 0				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	8 6;	19 10;	30 13					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	5 12;	17 3;	28 18					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	1 11;	9 3;	16 19;	24 11				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3		10 10;	20 13;	30 16				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	3 12;	11 5;	18 23;	26 16				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	3 20;	9 9;	14 22;	25 23				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 18;	14 8;	21 21;	29 11				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		12 8						
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	3 0;	10 11;	17 22;	25 9				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 18;	14 23;	22 4;	29 9				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	3 21;	11 19;	19 17;	27 14				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 17;	13 21;	24 1					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		11 11						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	3 3;	11 1;	19 0;	26 23				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	7 21;	14 14;	21 6;	27 23				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	6 5;	15 12;	24 18;	29 9				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	5 14;	14 8;	23 2;	27 11				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	5 14;	12 9;	19 3;	26 22				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	9 16;	16 9;	23 23;	29 14				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	9 22;	18 14;	28 6					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 15;	10 15;	18 14;	26 13				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	9 4;	15 22;	22 15;	29 9				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4 16;	10 22;	22 4;	27 23				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	9 19;	14 12;	23 21;	28 13				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		13 10;	30 17					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	3 0;	11 5;	19 11;	27 15				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	7 13;	14 13;	21 14;	28 14				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	2 6;	10 12;	18 17;	26 22				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 13;	9 1;	21 0;	25 12				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 1;	9 14;	17 3;	24 16				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 5;	13 15;	21 1;	28 11				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	5 0;	11 18;	18 13;	25 8				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	5 16;	14 0;	19 8;	25 16				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	2 19;	12 13;	22 7					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	7 18;	16 14;	25 11;	29 21				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	7 9;	13 10;	19 12;	25 13				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 4;	14 4;	21 4;	28 5				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	7 23;	25 2						
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	5 20;	13 10;	21 1;	28 15				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	7 9;	13 4;	24 17;	30 11				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 14;	10 8;	23 19;	30 13				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	3 19;	14 3;	24 12					
Y Lyrae	34 2	+43 52	11.3—12.3	0 12.1	6 3;	12 4;	24 5;	30 6				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 9;	9 13;	21 19;	27 22				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1919. November							
	h m	° ′		d h	d h	d h	d h	d h				
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	4 4;	10 3;	16 1;	27 23				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	3 6;	12 8;	21 10;	30 12				
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	2 11;	9 12;	23 13;	30 14				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	4 21;	11 21;	18 21;	25 21				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	5 2;	13 1;	21 1;	29 0				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7 22;	15 15;	23 7;	31 0				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	6 3;	13 7;	20 11;	27 16				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	5 3;	13 12;	21 21;	30 6				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3 12;	16 4;	22 11;	28 19				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	3 18;	20 3						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	5 13;	9 23;	18 20;	27 17				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2 13;	9 7;	22 18;	29 11				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	5 17;	13 10;	19 3;	25 20				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	7 16;	22 19						
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	2 9;	10 6;	18 2;	25 23				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	7 0;	13 22;	20 19;	27 16				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	2 20;	7 16;	17 10;	27 3				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	6 21;	15 13;	24 5					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	5 7;	10 16;	21 9;	26 18				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	9 13;	20 11						
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	3 5;	9 15;	22 11;	28 21				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	5 1;	10 1;	20 0;	29 23				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	2 21;	13 19;	24 16;	30 3				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	7 23;	12 11;	17 21;	28 18				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	6 8;	12 15;	18 22;	25 5				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	9 12;	21 16						
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	8 6;	15 5;	22 5;	29 5				

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, July and August, 1919.

Attention is called to the Annual Meeting of the Association which is to be held at the Harvard College Observatory, Cambridge, Massachusetts, on Saturday, November 8, 1919.

The Association was well represented at the recent meeting of the American Astronomical Society at Ann Arbor, Michigan.

Mr. Howard Eaton, an active observer in pre-war days, is to spend the coming year at the Harvard Observatory, where he will undertake the selection and measurement of comparison stars for sequences of special long period variables which should be added to our observing list. Mr. Eaton has kindly consented to prepare the tabulated observations for these reports. This, his first list, is the longest of the year, and is a most creditable one.

SS Cygni 213843 was at maximum on September 4, and the next rise may be expected about October 10. This variable is acting in a very erratic manner at present, and requires close attention by all who are able to observe it.

Variable Star Observations, July and August, 1919.

July 0 = 2422140 Aug. 0 = 2422171 Sept. 0 = 2422402

001046
X Androm.

J.D.	Est.	Obs.
242		
2167.7	<14.0	M

001032
S Sculptoris

2112.7	11.7	δ
2161.7	12.4	

001755
T Cassiop.

2143.8	10.8	M
68.7	9.0	B
78.8	9.5	M
93.6	8.7	B

001726
T Androm.

2143.8	10.2	M
78.8	8.2	
94.6	8.6	B
94.6	8.6	Cl
94.6	9.0	K
2207.7	8.7	E

001838
R Androm.

2167.7	12.8	M
70.3	11.2	Pe
2207.7	9.7	E

001909
S Ceti

2166.8	12.3	M
78.8	12.0	

002438
T Sculptoris

2112.7	11.5	δ
61.7	9.5	

002546
T Phoenicis

2112.7	<13.5	δ
61.7	14.	

002614
T Piscium

2166.8	10.5	M
78.8	9.8	

003179
Y Cephei

2156.8	10.2	M
63.6	10.5	B
65.6	10.4	Ba
78.8	10.2	M

004047
U Cassiop.

J.D.	Est.	Obs.
242		
2143.8	10.8	M
60.3	9.6	M_2
68.7	9.4	B
78.8	9.7	M
93.6	9.1	B
2207.8	9.8	E

004132
RW Androm.

2156.8	<12.0	M
2207.7	<12.5	E

004435
V Androm.

2163.8	10.3	M
67.9	10.9	V
73.7	11.2	B
78.8	11.6	M
98.7	12.7	B

004533
RR Androm.

2178.8	<11.6	M

004746a
RV Cassiop.

2163.8	11.3	M
68.7	11.7	B
78.8	11.8	M
91.6	12.5	B

004746b
— Cassiop.

2163.8	11.3	M

004958
W Cassiop.

2156.8	10.3	M
68.7	8.9	B
79.8	9.6	M
93.6	8.8	B
2207.7	9.3	E

010940
U Androm.

2163.8	10.7	M
79.8	10.2	
94.6	10.1	B
94.6	9.9	Cl
94.6	9.9	K

011041
UZ Androm.

2163.8	<11.5	M

011272
S Cassiop.

2170.7	<13.5	B

011208
S Piscium.

J.D.	Est.	Obs.
242		
2167.8	<11.6	V

012350
RZ Persei.

2198.7	11.0	B

012502
R Piscium

2193.9	9.0	M

013238
RU Androm.

2166.8	10.8	M
93.8	10.4	

013338
Y Androm.

2166.8	10.5	M
93.8	<11.7	

014958
X Cassiop.

2147.8	12.1	M
67.7	11.9	
73.7	10.7	B
78.8	11.3	M

015354
U Persei.

2163.8	8.6	M
73.7	8.5	B
78.8	8.8	M
78.9	8.6	Pt.

015912
S Arietis

2166.8	<12.3	M

021024
R Arietis

2166.8	12.4	M
98.7	10.1	B
98.8	10.3	M

021143a
W Androm.

2163.8	7.6	M
94.6	8.9	B
94.6	9.1	Cl
94.6	9.3	K
99.9	8.9	M

021281
Z Cephei

2179.6	<13.5	B

021403
o Ceti.

J.D.	Est.	Obs.
242		
2166.9	3.2	Pt
68.3	3.2	M_2
68.8	3.3	Pe_1
71.5	3.4	Ja
78.8	3.0	M
78.9	3.0	Pt
98.8	3.3	M
98.9	3.2	Pt

021558
S Persei.

2166.8	9.4	M
73.6	9.1	B
93.8	9.3	M

022000
R Ceti.

2198.9	7.9	M

022150
RR Persei

2198.7	13.6	B

023080
RR Cephei

2166.8	<12.5	M

023133
R Trianguli

2169.8	11.4	M
91.8	10.2	

024356
W Persei

2143.8	9.0	M
66.9	9.4	Pt
73.7	9.0	B
78.8	8.8	M
78.9	9.3	Pt

025050
R Horolog.

2161.7	9.1	δ

025751
T Horolog.

2161.7	8.3	δ

030514
U Arietis

2178.8	9.6	M
2206.7	12.8	E

031401
X Ceti

2178.8	10.7	M
2206.7	9.1	E

032043
Y Persei

2166.8	10.0	M

Y Persei

J.D.	Est.	Obs.
242		
2166.9	9.7	Pt
78.8	9.4	M
98.9	8.7	Pt
2206.7	8.4	E

032335
R Persei

2194.8	12.5	M

033362
U Camelop.

2178.8	8.4	M

041619
T Tauri

2166.8	<10.4	M
78.9	9.7	
98.9	10.0	

042215
W Tauri

2178.9	10.7	M
94.9	10.2	
98.9	10.0	

042209
R Tauri

2178.9	<11.0	M

042309
S Tauri

2178.9	<11.0	M

043065
T Camelop.

2178.8	9.0	M

043274
X Camelop.

2178.8	11.0	M

043208
RX Tauri

2198.9	10.1	M
2206.8	9.2	E

043263
R Reticuli

2161.7	10.5	δ

043562
R Doradus

2161.7	6.2	δ

044349
R Pictoris

2161.7	9.0	δ

VARIABLE STAR OBSERVATIONS, July and August, 1919—Continued.

044617
V Tauri
J.D. Est. Obs.
242
2199.9 11.2 M

050003
V Orionis
2194.9 10.9 M

050953
R Aurigae
2194.8 < 12.4 M

052034
S Aurigae
2199.9 9.8 M

052404
S Orionis
2194.9 < 11.2 M

053068
S Camelop.
2199.9 10.0 M

053005*a*
T Orionis
2194.9 10.1 M

053326
RR Tauri
2198.9 12.2 M

054319
SU Tauri
2198.9 9.4 M

054974
V Camelop.
2199.9 < 12.2 M

054920
U Orionis
2194.9 7.9 M
98.9 7.8 Pt

055353
Z Aurigae
2198.9 10.6 M

055686
R Octantis
2112.7 7.1 δ
60.1 8.1 δ_2

060450
X Aurigae
2199.9 9.4 M

060547
SS Aurigae
2199.9 < 12.4 M
2206.9 < 12.4 E

061702
V Monoc.
J.D. Est. Obs.
242
2198.9 9.6 M

090151
V Urs. Maj.
2129.8 10.6 Pe_2

091868
RW Carinae
2112.7 10.9 δ
35.6 12.2 Tp
60.0 12.8 δ_2

092962
R Carinae
2160.0 7.8 δ_2
35.6 8.7 Tp

094211
R Leonis
2112.4 8.5 Ja
18.4 8.9

094262
l Carinae
2135.6 4.3 Tp
60.0 3.9 δ_3

100661
S Carinae
2135.6 8.2 Tp
60.0 7.8 δ_4

103769
R Urs. Maj.
2130.3 10.8 Pe
67.6 11.7 Ba
67.7 11.6 M
70.6 11.6 B
2200.5 12.4

114441
X Centauri
2136.1 8.0 Tp_2
36.6 7.9 δ
60.0 8.1 δ_2

115919
R Com. Ber.
2129.9 8.0 Ja_2
43.4 8.7 Ja
44.6 8.8 M
65.6 9.0 Ba

120012
SU Virginis
2129.4 12.6 Ja

122001
SS Virginis
2167.6 7.1 Ba

122532
T Can. Ven.
J.D. Est. Obs.
242
2144.6 9.6 M
69.6 8.2 Ba

123160
T Urs. Maj.
2132.4 < 12.5 Pe_2
67.6 12.8 Ba
67.7 12.5 M
70.7 13.0 B
71.3 12.5 Pe

123307
R Virginis
2167.6 8.0 Ba

123459
RS Urs. Maj.
2130.7 9.0 Pe_3
44.6 8.5 M
62.7 8.5 Mu
67.6 8.8 Ba
70.7 9.0 B
71.3 9.1 Pe
74.6 9.1 M

123961
S Urs. Maj.
2130.7 11.4 Pe_3
44.6 10.0 M
62.7 9.4 Mu
65.7 8.8 Ba
70.6 8.8 B
71.3 9.0 Pe
74.6 8.6 M
92.6 8.6 My_2
96.7 8.7 Pt
98.1 8.3 My_4
2200.6 7.9 B

124204
RU Virginis
2167.6 < 13.0 Ba

124606
U Virginis
2072. 12.0 Pa
93. 14.± Pa
2167.6 9.5 Ba

131283
U Octantis
2135.6 11.9 Tp
60.1 10.6 δ_2

132422
R Hydrae
2158.0 7.2 δ_2

132706
S Virginis
J.D. Est. Obs.
242
2112.4 9.8 Ja
29.4 11.3

133633
T Centauri
2136.1 6.4 Tp_2
36.6 6.3 δ
60.0 6.3 δ_3
65.6 6.3 Tp

134236
RT Centauri
2135.6 9.6 Tp
60.0 8.9 δ_2

134440
R Can. Ven.
2144.6 7.5 M
67.6 7.5 Ba
67.7 8.0 Pt
73.6 7.3 B
73.6 7.2 Cl
73.6 7.1 K
74.6 7.8 M
96.7 8.0 Pt
2200.6 7.5 B

134677
T Apodis
2135.6 12.8 Tp
60.0 < 13.2 δ_2

135908
RR Virginis
2013. < 13.6 Pa
23. 11.0
72. 12.2
93. 13.1
2110. 13.8 Pa_2
35. < 15. Pa
60. < 16.?

140113
Z Bootis
2167.7 14.0 M

140528
RU Hydrae
2161.6 12.7 δ

140959
R Centauri
2112.7 6.9 δ
35.6 7.1 Tp
35.8 7.5 δ
60.1 8.0 δ_4
65.6 8.0 Tp

141567
U Urs. Min.
J.D. Est. Obs.
242
2153.6 8.6 M
67.6 7.8 Ba
70.6 7.9 B

141954
S Bootis
2072. 11.2 Pa
93. 10.2
2153.6 8.6 M
67.6 8.4 Ba
92.6 9.3 B
99.7 9.2 Pt

142205
RS Virginis
2129.4 8.0 Ja
44.6 8.3 B
67.6 9.5 Ba
68.6 9.5 B

142584
R Camelop.
2122.6 8.2 My
53.6 9.6 M
67.6 9.4 Ba
70.6 10.0 B

142539
V Bootis
2144.6 8.0 B
53.6 7.8 M
66.7 8.6 Pt
67.6 8.5 Ba
68.6 8.0 B
68.6 9.0 Wg
74.6 8.5 M
90.7 9.5 Pt
92.6 9.3 B

143227
R Bootis
2153.6 7.2 M
56.7 7.4 Pt
60.2 7.4 Su_2
67.6 7.2 Ba
68.6 6.9 B
73.3 7.1 Pe
74.6 8.0 M
86.7 8.6 Pt
92.6 8.6 B

144918
U Bootis
2153.6 10.7 M
57.7 10.7 V
67.6 10.4 Ba
69.6 10.4 B
90.6 10.7 V
92 6 10.6 B

VARIABLE STAR OBSERVATIONS, July and August, 1919—Continued.

150018
RT Librae
J.D. Est.Obs.
242
2167.6 11.4 Ba

150519
T Librae
2167.6<12.8 Ba

150605
Y Librae
2167.6 12.0 Ba

151520
S Librae
2167.6 9.5 Ba

151731
S Cor. Bor.
2147.8 12.2 M
67.6 12.3 Ba
68.7 12.6 B
93.6 12.7
2202.6 12.4 M

151714
S Serpentis
2153.6 8.8 M
67.6 8.9 Ba

151822
RS Librae
2127. 8.8 Pa
67.6 11.1 Ba
70.6 11.0 B

152714
RU Librae
2128. 14.2 Pa
39. 14.1
67.6 12.8 Ba

152849
R Normae
2135.6 12.3 Tp
60.1 12.6 δ_2
60.6 12.5 Tp
65.6 12.6

153378
S Urs. Min.
2169.7 10.4 B
73.6 9.9 Ba

153654
T Normae
2135.6 13.0 Tp
60.1 13.4 δ_2

124336
X Cor. Bor.
2192.6 10.4 B

154428
R Cor. Bor.
J.D Est.Obs
242
2115.6 5.9 My
16.5 5.6 Ja
17.6 6.0 My
22.6 6.0
24.6 6.0
27.5 5.7 Ja
30.4 6.1 Pe
31.6 5.9 My
32.4 6.0 Pe
40.6 6.1 My
41.7 6.3 Pt
42.6 6.1 My
42.6 6.0 Wg
42.7 6.3 Pt
42.8 6.4 Mu
43.6 6.2 My
43.7 6.4 Pt
43.8 6.2 M
47.7 6.4 Pt
47.8 6.2 M
48.6 6.3 My
56.7 6.4 Pt
57.6 6.1 V
57.7 6.4 Pt
57.7 6.2 Mu
58.3 6.1 Pe
62.7 6.2 Mu
62.7 6.4 Pt
63.6 6.3 My
63.6 6.0 Wg
63.7 6.2 Mu
65.6 6.0 Ba
65.7 6.2 Mu
66.6 6.0 Bn
66.7 6.4 Pt
67.6 6.0 Ba
67.7 6.4 Pt
68.6 6.0 My
68.7 6.5 Pt
69.6 6.0 Ba
69.6 6.0 Wg
70.3 6.0 Pe
72.6 6.0 Ba
73.6 5.9
74.6 6.2 M
79.6 6.2 My
80.6 6.2
85.7 6.2 Pt
86.7 6.3
89.7 6.3 Mu
90.6 6.2 V
90.7 6.2 Pt
91.6 6.0 My
92.7 6.3 Pt
93.6 6.0 My
93.6 6.1 Bn
94.7 6.3 Pt
96.6 6.1 Bn
96.6 6.1 My

R Cor. Bor.
J.D. Est. Obs.
242
2196.7 6.2 Mu
97.6 6.2 My
98.6 6.3
99.6 6.3
99.6 6.3 Pt
99.7 6.2 Mu
2202.6 6.3 Pt
02.6 6.4 M
02.7 6.3 Mu

154536
X Cor. Bor.
2147.8<12.2 M
67.6 11.0 Ba
92.6 10.4 B

154639
V Cor. Bor.
2147.8 10.0 M
67.6 8.8 Ba
74.6 10.6 M

154615
R Serpentis
2112.4 8.9 Ja
29.4 9.4
32.4 10.3 Pe
42.7 10.5 Pt
44.6 10.1 B
46.5 10.2 Ja
48.8 10.5 M
58.6 10.9 V
65.7 11.4 B
69.0 11.6 Ja_2
70.3<12.4 Pe
73.6 11.6 Ba
79.6 11.9 B
88.6 11.2 M

154715
R Librae
2127. 12.6 Pa

154736
R Lupi
2160.1 12.1 δ_2

155018
RR Librae
2139. 8.6 Pr
60. 8.8

155229
Z Cor. Bor.
2167.6 10.3 Ba
93.6 9.6 B

155823
RZ Scorpii
2173.6 9.8 Ba

155947
X Herculis
J.D. Est.Obs.
242
2142.6 6.2 Wg
42.8 6.5 Mu
61.4 6.2
65.7 6.2
69.6 5.6 Wg
73.6 5.9 Ba
89.7 6.2 Mu
96.7 6.1
99.7 6.1
2202.7 6.2

160021
Z Scorpii
2128. 12.1 Pa
38. 12. Pr

160118
R Herculis
2169.0 12.6 Ja_2
73.6 10.9 Ba
93.6 8.8 B

160210
U Serpentis
2167.6 10.4 Ba
93.6 11.7 B

160221
X Scorpii
2131. 10.3 Pa

160519
W Scorpii
2072. <15. Pa
2107. 13.
24. 13.
28. 12.4
38. 12.5 Pa_3
53. 12.7 Pa
60. 13.2

160625
RU Herculis
2128. 10.7 Pa
30.5 10.8 Ja
47.8 11.4 M
67.6 11.8 Ba
68.4 11.8 Ja
69.7 11.7 B
91.7 12.3

161138
W Cor. Bor.
2167.6<12.5 Ba

161122a
R Scorpii
2111.5 11.1 Ja
16.5 10.9
29.9 11.2 Ja_2
43.4 12.1 Ja
73.6<12.5 Ba

161122b
S Scorpii
J.D. Est.Obs.
242
2111.5 11.3 Ja
16.5 11.8
32.4 13.0

161122c
T Scorpii
2173.6 11.0 Ba

161607
W Ophiuchi
2140. 11.6 Pr_2
60. 11.3 Pr
69.6 11.2 B
73.6 11.3 Ba
99.5 11.0 B

162119
U Herculis
2147.8 12.3 M
69.7 12.0 B
70.9 11.4 Pe_2
73.6 11.6 Ba
93.7 11.7 B
2202.6 10.3 M

162112
V Ophiuchi
2170.6 8.3 B
73.6 7.9 Ba

162319
Y Scorpii
2107. <15.5 Pa
35. <15.5
40.5 15. Pa_2
60. 14.5 Pa

162542
g Herculis
2142.8 5.2 Mu
61.4 4.8
65.7 4.9
89.7 4.9
96.7 5.1
99.7 5.1
2202.7 4.9

162807
SS Herculis
2167.6 11.5 Ba
78.6 11.7 B

162816
S Ophiuchi
2173.6 9.7 B

163172
R Urs. Min.
2170.6 9.4 B
73.6 9.4 Ba
88.6 10.5 M

VARIABLE STAR OBSERVATIONS, July and August, 1919—Continued

163137
W Herculis

J.D. 242	Est.	Obs.
2118.5	9.8	Ja
29.5	10.9	
43.4	11.6	
46.5	11.7	
47.8	12.0	M
68.5	13.0	Ja_2
73.6	12.9	Ba

163266
R Draconis

2173.6	8.0	Ba
88.6	8.1	M
94.6	8.2	B
94.6	8.0	Cl
94.6	8.2	K
99.7	8.0	Pt

164055
S Draconis

2143.8	9.2	M
56.7	9.0	Pt
73.6	8.8	Ba
88.6	9.1	M
94.7	9.0	Pt

164319
RR Ophiuchi

2144.6	10.3	B
68.6	11.3	
73.6	11.5	Ba
99.5	12.3	B

164715
S Herculis

2166.7	8.4	Pt
73.6	8.1	Ba
78.6	7.8	B
86.7	8.5	Pt
88.6	8.2	M

164844
RS Scorpii

2135.6	11.3	Tp
60.1	11.8	δ_2
60.6	11.7	Tp

165030
RR Scorpii

2112.7	10.7	δ
35.6	10.2	Tp
60.2	10.7	δ_2
60.6	9.8	Tp

165202
SS Ophiuchi

2173.6	9.0	Ba

165631
RV Herculis

2131.0	12.6	Ja_2
43.4	11.8	Ja

RV Herculis

J.D. 242	Est.	Obs.
2146.5	11.7	Ja
47.8	11.5	M
68.4	11.4	Ja_2
69.6	11.0	Ba
72.8	11.2	M
78.6	11.3	B
88.6	11.3	M

170215
R Ophiuchi

2141.7	8.3	Mu
44.6	7.8	B
62.7	7.3	Mu
62.7	7.2	Pt
70.6	7.2	Wg
70.9	7.3	Pe_2
73.6	7.0	Ba
92.7	7.8	Pt

170627
RT Herculis

2169.6	10.1	Ba
93.6	10.4	B

171401
Z Ophiuchi

2112.4	9.5	Ja
29.5	9.6	
37.	9.4	Pr
43.4	9.7	Ja
58.6	10.5	V
65.7	10.0	B
66.4	10.3	Ja
73.6	10.2	Ba
76.6	10.9	B
90.6	11.3	V

171723
RS Herculis

2129.5	9.2	Ja
69.0	12.0	Ja_2
69.6	11.8	Ba
91.7	12.4	B

172586
S Octantis

2135.7	10.0	Tp
61.6	11.6	δ

172809
RU Ophiuchi

2165.7	12.2	B
69.6	12.2	Ba
79.6	11.7	B

175111
RT Ophiuchi

2159.6	9.0	B
59.6	9.0	Cl
65.6	9.0	Ba
99.5	9.6	B

175458a
T Draconis

J.D. 242	Est.	Obs.
2147.8	11.0	M
65.6	12.1	Ba
93.7	11.1	B

175458b
UY Draconis

2147.8	10.3	M
65.6	10.9	Ba

175519
RY Herculis

2171.4	9.4	Pe
73.6	9.4	Ba
93.6	9.1	B

175654
V Draconis

2147.8	11.9	M

180363
R Pavonis

2160.6	11.5	Tp
61.7	11.3	δ

180531
T Herculis

2163.	11.2	Pr
67.7	10.6	V
72.8	9.4	M
73.6	9.4	Ba
90.6	8.5	V
93.6	8.3	B
93.7	7.9	M
94.7	8.4	Pt
98.1	8.4	My_4

181136
W Lyrae

2144.7	10.5	M
66.4	12.0	Ja
73.6	12.0	Ba
89.8	12.4	M
93.7	12.1	B

181103
RY Ophiuchi

2169.6	9.0	B
73.6	8.6	Ba
93.6	8.1	B

182133
RV Sagittarii

2112.7	13.0	δ
60.6	12.5	Tp
61.7	12.7	δ

182224
SV Herculis

2169.6	< 13.6	Ba

182306
T Serpentis

J.D. 242	Est.	Obs.
2137.	12.2	Pr
59.	11.6	
65.6	12.7	B
79.6	12.4	
96.6	< 12.5	

183225
RZ Herculis

2169.6	11.4	Ba

183308
X Ophiuchi

2144.7	6.6	M
65.7	6.8	B
73.6	6.8	Ba
73.6	7.3	B

184243
RW Lyrae

2207.6	13.9	E

184205
R Scuti

2111.4	6.7	Pe
11.5	6.8	Ja
12.5	6.7	
14.4	6.6	Pe
16.5	6.6	Ja
17.4	6.4	
18.4	6.3	
19.4	6.2	
19.4	6.5	Pe
27.4	5.6	Ja
29.4	5.5	Pe
29.5	5.2	Ja
30.4	5.5	Pe
30.5	5.3	Ja
32.5	5.2	
40.6	5.0	My
41.5	5.1	Ja
41.7	5.2	Pt
42.6	4.9	My
42.7	4.7	Su
42.7	5.1	Pt
42.8	4.5	Mu
43.4	5.0	Ja
43.6	4.9	My
43.7	5.3	Pt
46.4	5.0	Ja
47.7	5.1	Pt
47.8	4.8	M
48.6	4.9	My
49.7	4.9	Pt
55.7	5.1	
56.7	5.3	
57.7	4.8	Mu
57.7	5.3	Su
57.7	5.5	Pt
58.3	5.7	Pe
58.4	5.4	Ja

R Scuti

J.D. 242	Est.	Obs.
2162.7	5.6	Su
62.7	5.8	Pt
62.7	6.0	Mu
63.6	5.3	My
63.7	5.9	Mu
65.4	5.8	Ja
65.6	5.8	Ba
65.7	5.8	Mu
66.3	5.8	Pe
66.7	5.7	Pt
67.3	5.8	Pe
67.6	5.9	Ba
67.7	5.7	Pt
68.3	5.8	Pe
68.6	5.8	My
68.7	5.8	Pt
68.7	5.5	Su
69.3	5.8	Pe
69.6	6.0	Wg
70.6	5.8	Bn
71.5	5.8	Ja
71.7	5.8	Pt
72.8	5.0	M
73.6	5.9	Ba
78.7	5.7	Pt
79.6	5.9	My
80.6	6.0	
85.7	6.3	Pt
86.7	5.9	
89.7	5.9	Mu
90.7	5.9	Pt
91.6	6.2	My
92.7	5.6	Pt
93.6	6.3	My
93.6	6.0	Bn
93.7	5.8	Pt
94.7	5.7	
96.6	6.2	My
96.6	6.0	Bn
96.7	5.9	Mu
96.7	5.6	Pt
97.6	6.2	My
98.6	6.3	
98.7	5.6	Pt
99.6	5.8	
99.6	6.4	My
99.7	5.4	Mu
2200.7	5.5	
02.6	5.7	Pt
02.6	5.0	M
02.7	5.4	Mu

184208
S Scuti

2144.7	7.2	Mu

VARIABLE STAR OBSERVATIONS, July and August, 1919—Continued

184300
Nova Aquilae

J.D.	Est.	Obs.
242		
2111.4	6.6	Pe
18.4	6.7	Ja
19.4	6.5	Pe
27.5	6.8	Ja
29.4	6.5	Pe
30.4	6.6	
30.5	6.8	Ja
40.6	6.2	My
42.6	6.2	
42.7	6.4	Pt
43.6	6.2	My
44.7	6.8	B
46.5	6.9	Ja
47.8	6.8	M
48.6	6.2	My
56.7	6.4	Pt
57.6	7.6	V
57.7	6.4	Pt
58.4	6.8	Ja
62.7	6.6	Pt
63.6	6.9	B
64.6	6.9	
65.6	6.3	Ba
65.6	6.9	B
66.3	6.9	Pe
66.7	6.4	Pt
67.7	6.6	
68.3	6.8	Pe
68.6	6.0	My
68.7	6.6	Pt
69.6	6.8	B
71.5	6.7	Ja
71.7	6.6	Pt
72.8	6.9	M
78.6	7.0	B
78.9	6.7	Pt
79.6	6.1	My
80.6	6.1	
85.7	6.6	Pt
86.7	6.7	
90.6	7.5	V
90.7	6.7	Pt
91.6	6.1	My
91.6	7.1	B
92.7	6.9	Pt
93.6	6.2	My
93.7	7.0	Pt
94.6	7.3	B
94.7	7.0	Pt
96.6	6.3	My
96.7	7.0	Pt
97.6	6.3	My
98.6	6.4	
99.6	6.3	
99.6	7.1	Pt
2202.6	7.0	
02.6	7.2	M

185032
RX Lyrae

J.D	Est.	Obs.
242		
2172.8	<12.5	M

185243
R Lyrae

J.D.	Est.	Obs.
2157.7	4.2	Mu
62.7	4.1	
65.7	4.1	
99.7	4.2	
2202.7	4.2	

185634
Z Lyrae

J.D.	Est.	Obs.
2147.8	9.5	M
72.8	10.7	
93.7	12.2	B

185905
V Aquilae

J.D.	Est.	Obs.
2162.7	6.9	Mu

190108
R Aquilae

J.D.	Est.	Obs.
2146.5	10.9	Ja
63.6	10.6	B
66.4	11.3	Ja
98.6	10.3	B

190529a
V Lyrae

J.D.	Est.	Obs.
2118.5	13.0	Ja
91.8	<12.4	M

190818
RX Sagittarii

J.D.	Est.	Obs.
2165.6	12.2	B
91.6	13.3	

190819a
RW Sagittarii

J.D.	Est.	Obs.
2165.6	10.3	B
91.6	10.4	

190967
U Draconis

J.D.	Est.	Obs.
2147.8	10.4	M
98.8	11.6	

190926
X Lyrae

J.D.	Est.	Obs.
2191.8	8.7	M

190925
S Lyrae

J.D.	Est.	Obs.
2169.6	14.0	Ba

191017
T Sagittarii

J.D.	Est.	Obs.
2159.	11.8	Pr

191019
R Sagittarii

J.D.	Est.	Obs.
2166.7	7.6	Pt
68.6	8.4	B
90.7	8.6	Pt

191033
RY Sagittarii

J.D.	Est.	Obs.
242		
2112.7	6.7	δ
30.5	6.7	Tp
35.8	7.0	δ
60.6	6.7	Tp
61.7	6.7	δ
61.7	7.0	δ
65.6	6.6	Tp
65.6	7.0	Ba

191124
TY Sagittarii

J.D.	Est.	Obs.
2112.7	11.8	δ
60.6	9.7	Tp
61.7	10.2	δ
65.6	10.3	Tp

191133
—Sagittarii

J.D.	Est.	Obs.
2130.5	9.4	Tp
60.6	9.1	Tp
61.7	9.3	δ
65.6	9.0	Tp

191350
TZ Cygni

J.D.	Est.	Obs.
2165.6	10.4	Ba
91.8	10.6	M

191319
S Sagittarii

J.D.	Est.	Obs.
2163.	13.9	Pa

191321
Z Sagittarii

J.D.	Est.	Obs.
2135.	10.0	Pa

191637
U Lyrae

J.D.	Est.	Obs.
2166.5	11.5	Ja
72.8	10.9	M

193311
RT Aquilae

J.D.	Est.	Obs.
2169.6	13.8	B
97.6	13.1	

193449
R Cygni

J.D.	Est.	Obs.
2128.	13.3	Pa
35.	13.4	
51.	13.7	Pa_2
67.7	13.3	M
81.6	13.9	Pa

193509
RV Aquilae

J.D.	Est.	Obs.
2165.7	<13.0	Ba

193732
TT Cygni

J.D.	Est.	Obs.
242		
2157.7	8.4	Pt
59.6	7.7	B
59.6	7.9	Cl
72.8	8.5	M

193972
T Pavonis

J.D.	Est.	Obs.
2112.7	8.9	δ
60.6	11.3	Tp
61.7	11.6	δ

194048
RT Cygni

J.D.	Est.	Obs.
2142.3	7.0	Mu
44.7	8.0	M
48.6	6.9	Mu
56.7	7.0	Pt
58.7	>7.3	V
68.6	6.6	My
69.6	7.7	Ba
89.8	8.5	M
92.6	8.9	V
98.9	9.2	Pt

194348
TU Cygni

J.D.	Est.	Obs.
2144.7	9.0	M
58.7	9.0	V
69.6	9.8	Ba
89.8	10.5	M
92.6	10.2	V

194632
χ Cygni

J.D.	Est.	Obs.
2112.8	6.6	Pe_2
17.5	6.8	Ja_2
19.4	6.7	Pe
29.0	7.2	Ja_2
29.4	7.1	Pe_4
44.7	8.0	M
44.7	7.2	Mu
46.5	8.0	Ja
56.7	8.5	Pt
58.4	8.4	Ja
58.3	8.4	Pe
58.7	8.2	V
63.6	8.3	B
65.4	8.9	Ja
69.6	8.7	B_2
69.6	8.7	Cl_2
70.3	9.5	Pe
72.8	9.3	M
73.6	9.3	K
76.6	9.0	B_2
91.6	9.8	B
92.6	10.7	V
93.8	10.4	M
96.5	10.0	B
96.5	10.3	Cl
96.5	10.4	K
2207.6	10.4	E

194604
X Aquilae

J.D.	Est.	Obs.
242		
2144.7	11.5	M
69.6	13.4	Ba
98.6	<13.5	B

194659
S Pavonis

J.D.	Est.	Obs.
2112.7	9.6	δ
60.6	7.5	Tp
61.7	8.3	δ
65.6	8.4	Tp

194929
RR Sagittarii

J.D.	Est.	Obs.
2112.7	8.1	δ
61.7	10.2	

195116
S Sagittae

J.D.	Est.	Obs.
2142.8	5.2	Mu
57.7	6.1	
62.7	5.7	
63.7	6.0	
65.7	6.4	
69.6	5.6	Wg
70.6	5.8	Bn
89.7	6.0	Mu
93.6	6.0	Bn
96.6	6.1	
96.7	5.8	Mu
99.7	6.0	
2200.7	5.7	
02.7	5.3	

195202
RR Aquilae

J.D.	Est.	Obs.
2191.6	12.5	B

195308
RS Aquilae

J.D.	Est.	Obs.
2169.6	12.5	B
91.6	13.3	

195849
Z Cygni

J.D.	Est.	Obs.
2127.	10.5	Pa
31.4	9.6	Pe_2
40.	10.2	Pa
41.	10.2	Pr
44.7	9.8	M
58.7	9.4	V
59.6	9.0	B
59.6	8.9	Cl
67.7	9.2	Pt
69.6	8.6	Ba
89.8	9.4	M
92.6	9.3	V

200212
SY Aquilae

J.D.	Est.	Obs.
2168.6	12.0	B
69.6	12.1	Ba
91.6	12.6	B

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200357
S Cygni

J.D.	Est.	Obs.
242		
2169.8	10.9	M
89.8	11.0	

200647
SV Cygni

2165.7	9.5	Wg
72.8	9.1	M
94.8	8.3	

200715a
S Aquilae

2112.5	11.9	Ja
18.5	11.8	
31.0	11.4	
41.5	9.7	
46.4	9.8	
65.6	9.3	B
68.5	9.7	Ja
74.6	10.1	M
79.6	9.5	B

200715b
RW Aquilae

2112.5	9.1	Ja
18.5	9.1	
29.5	9.6	
43.8	8.8	M
65.6	9.2	B
74.6	9.3	M
79.6	9.2	B

200812
RU Aquilae

2168.6	10.6	B
69.6	10.9	Ba
72.8	10.8	M
76.6	11.4	B
98.6	12.4	

200822
W Capricorni

2172.8	<10.2	M

200938
RS Cygni

2143.7	7.4	Mu
68.7	8.3	Pt
72.2	7.9	M_2
74.6	7.7	M
96.7	8.2	Pt

200916
R Sagittae

2115.5	8.7	Ja_2
43.8	9.1	M
65.6	9.3	B
74.6	8.8	M

200906
Z Aquilae

J.D.	Est.	Obs.
242		
2138.4	9.2	Pr
46.5	10.5	Ja
63.6	11.2	B
65.5	11.5	Ja
91.6	12.8	B

201008
R Delphini

2143.8	9.7	M
44.6	9.4	B
65.6	10.4	
69.6	11.5	Ba
78.6	11.4	B
98.6	12.0	

201130
SX Cygni

2191.8	<12.4	M

201121
RT Capricorni

2143.7	7.3	Mu
66.7	7.8	Pt
72.8	7.5	M
94.7	8.0	Pt

201139
RT Sagittarii

2112.7	11.7	δ
61.7	9.7	

201647
U Cygni

2130.5	8.0	Ja
30.7	7.8	Pe_3
66.9	7.6	Pt
69.8	7.1	M
70.3	7.7	Pe
74.6	6.4	M
98.7	7.5	Pt

202240
U Microscopii

2112.7	11.3	δ
61.7	10.1	

202539
RW Cygni

2143.8	8.8	M
70.6	8.6	Wg
74.6	9.0	M

202817
Z Delphini

2165.6	12.3	B
69.6	12.0	Ba
79.6	11.6	B
98.6	11.1	

202954
ST Cygni

J.D.	Est.	Obs.
242		
2144.8	10.9	M
68.6	10.4	B
79.8	11.4	M

202946
SZ Cygni

2169.6	8.6	Ba
69.8	9.2	M
73.5	9.2	Ba
79.8	9.7	M
89.8	9.8	

203226
V Vulpeculae

2162.7	9.4	Pt
69.8	8.5	M
79.8	8.2	
90.7	8.9	Pt

203611
Y Delphini

2168.6	11.8	B
69.6	11.8	Ba
93.6	12.6	B

203847
V Cygni

2093.	10.	Pa
2117.	9.7	
28.	9.7	
69.8	11.0	M
79.8	11.4	

203816
S Delphini

2143.8	10.5	M
58.7	<11.5	V
69.6	11.0	B
91.6	10.8	

203905
Y Aquarii

2143.8	10.6	M
94.8	11.7	

204016
T Delphini

2143.8	<12.0	M
69.6	<13.0	Ba
98.6	14.1	B

204104
W Aquarii

2140.	13.5	Pr
59.	<13.4	
73.6	<13.8	B

204215
U Capric.

2195.7	15.7	Pa

204318
V Delphini

J.D.	Est.	Obs.
242		
2107.	15.	Pa
35.	<15.	
42.	*N*	
56.	*N*	
95.6	<16.	

204405
T Aquarii

2143.8	7.6	M
67.7	7.8	Pt
73.6	7.5	B
78.9	7.5	Pt
93.8	8.3	M

204846
RZ Cygni

2172.6	13.0	Ba
94.8	<12.4	M

205030a
UX Cygni

2194.8	11.7	M

205017
X Delphini

2163.6	9.0	B
76.6	9.6	
99.6	11.0	

205627
RR Capric.

2112.7	12.5	δ
61.7	8.2	

205923
R Vulpeculae

2169.8	9.7	M
79.8	9.3	
96.7	8.6	Pt

210129
TW Cygni

2110.	11.0	Pa
28.	11.8	
35.	11.8	
73.6	<13.3	Ba

210116
RS Capric.

2162.7	8.5	Pt
94.7	8.1	

210504
RS Aquarii

2137.	11.0	Pr

210868
T Cephei

2142.7	9.4	Pt
57.8	9.6	M
79.6	9.9	B
94.8	10.5	M

210812
R Equulei

J.D.	Est.	Obs.
242		
2165.7	<13.0	Ba

211615
T Capric.

2165.7	<12.0	Ba

212030
S Micros.

2112.7	9.9	δ
61.7	13.2	

212230
- - Micros.

1705.8	10.1	δ
1802.6	9.2	
1900.6	9.8	
48.5	9.3	
50.5	9.2	
2112.7	9.8	
61.7	9.9	

212814
Y Capric.

2163.	14.5	Pa

213244
W Cygni

2170.3	6.8	Pe

213753
RU Cygni

2142.8	9.4	M
78.8	9.0	

213843
SS Cygni

2116.5	10.8	Ja
17.4	11.1	
18.5	11.5	
27.4	11.4	
29.4	9.7	Pe
30.4	9.5	
30.5	9.1	Ja
32.4	8.7	Pe
32.5	8.6	Ja
42.4	10.1	
42.8	10.4	M
43.8	10.5	
44.6	10.3	B
44.8	10.2	M
45.6	10.4	B
46.4	11.0	Ja
47.8	10.7	M
51.4	11.1	Ja
53.8	10.8	M
56.7	9.7	Pt
57.7	9.5	
58.4	10.3	Ja
59.6	9.8	Cl
59.6	9.7	B

VARIABLE STAR OBSERVATIONS, July and August, 1919—Continued.

SS Cygni

J.D. 242	Est.	Obs.
2163.6	10.4	B
64.6	11.1	
65.4	11.1	Ja
65.6	11.3	B
65.6	10.9	Ba
66.4	11.0	Ja
66.8	11.5	M
67.6	11.4	Ba
67.8	11.4	M
68.6	11.3	B
69.6	11.4	
69.6	11.5	Ba
69.8	11.4	M
70.3	11.8	Pe
70.6	11.5	B
71.4	11.1	Ja
72.6	11.4	Ba
72.8	11.5	M
73 5	11.6	Ba
73.6	11.4	B
73.6	11.1	K
73.6	11.0	Cl
75.6	11.5	B
76.6	11.5	
78.6	11.3	
78.8	11.2	M
79.6	11.0	B
79.8	11.0	M
80.6	11.4	B
82.6	11.4	
88.6	11.3	M
89.8	11.6	
90.7	11.1	V
91.6	11.5	B
92.6	11.5	
93.6	11.5	
94.6	11.6	
94.6	11.7	K
94.6	11.6	Cl
94.8	12.1	M

SS Cygni

J.D. 242	Est.	Obs.
96.5	11.6	B
96.5	11.8	K
96.5	11.5	Cl
97.6	11.6	B
98.6	11.5	
2200.5	11.6	
06.5	8.6	E
06.8	8.3	M
07.5	8.4	E
08.7	8.2	M
09.6	8.3	

213937
RV Cygni

2143.7	6.6	Mu
43.8	7.9	M
57.7	7.9	Pt
74.6	7.9	M
86.7	7.8	Pt

214024
RR Pegasi

2165.6	13.5	Ja
98.6	13.8	B

214247
R Gruis

2112.7	12.1	δ
61.7	13.2	

215605
V Pegasi

2167.7	9.6	V
94.8	11.5	M
99.6	11.3	B

215934
RT Pegasi

2194.8	11.0	M

220412
T Pegasi

J.D. 242	Est.	Obs.
2178.6	11.1	B

220613
Y Pegasi

2178.6	11.4	B

220613
Y Pegasi

2178.6	11.4	B

221948
S Gruis

2112.7	9.2	δ
61.7	7.8	δ_2

222439
S Lacertae

2194.6	8.7	B
94.6	8.5	Cl
94.6	8.9	K
98.8	8.4	M

223462
T Tucanae

2112.7	8.6	δ
61.7	9.1	

223841
R Lacertae

2198.8	< 12.4	M

225914
RW Pegasi

2167.8	10.4	V
70.7	10.4	B
94.8	12.5	M
96.6	12.6	B
96.6	12.7	Cl
96.6	12.5	K

230110
R Pegasi

J.D. 242	Est.	Obs.
2116.5	12.8	Ja
79.8	10.6	M

230759
V Cassiop.

2130.4	9.4	Pe
57.8	7.9	M
58.4	7.5	Pe
62.7	7.6	Pt
67.8	7.7	V
68.7	7.6	B
70.4	7.3	Pe
86.7	7.9	Pt
90.7	8.4	V
94.6	8.4	B

231425
W Pegasi

2172.8	10.9	M
94.8	11.6	

231508
S Pegasi

2170.4	12.2	Pe
70.7	11.9	B

232746
V Phoenicis

2112.7	11.7	δ
61.7	< 13.6	

233335
ST Androm.

2156.8	10.3	M
79.8	10.4	
94.6	10.4	K
94.6	10.4	B

233956
Z Cassiop.

2165.7	13.0	Ba

235053
RR Cassiop.

J.D. 242	Est.	Obs.
2143.6	11.2	B
56.8	11.0	M
99.9	11.3	

235150
R Phoenicis

2112.7	12.3	δ
61.7	< 13.8	

235350
R Cassiop.

2157.8	7.5	M
67.8	7.8	V
68.7	7.8	B
90.7	7.9	V
93.6	7.9	B
99.9	9.7	M

235525
Z Pegasi

2156.8	8.6	M
79.8	8.8	

235855
Y Cassiop.

2190.7	< 11.0	V
95.7	11.0	Pa

235939
SV Androm.

2198.7	13.1	B

No. of Observations: 1284. No. of Stars Observed: 288. No. of Observers: 19.

Rev. Luis Rodés, S. J., after spending three years in the United States, has started for Spain, and intends to continue his interest in variable stars in that country. We wish him a pleasant journey.

Attention is called to the ephemeris of Algol, by Mr. W. A. Mason, in the September number of the Monthly Evening Sky Map.

Our observations are to be greatly benefitted by contributions from Professor J. A. Parkhurst, who observes with the 40-inch Telescope at Yerkes Observatory. These reports will doubtless fill in many gaps when variables are faint. Professor Parkhurst has the designation "Pa."

Other new contributors in this report are:

Mr. E. W. Clement, Hudson, New Hampshire, "Cl."
Mr. T. S. Kimball, Nashau, New Hampshire, "K"
Miss H. McW. Parsons, Yerkes Observatory, "Pr."

The following observers contributed to this report:—Messrs. Bancroft, Bouton, Brown, Clement, Dawson, Eaton, Janczewski, Kimball, McAteer, Mundt, Murray, Parkhurst, Peltier, de Perrot, Tapia, Suter, Vrooman, Woglom, and Miss Parsons.

IDA E. WOODS,
Acting Secretary.

COMET AND ASTEROID NOTES.

The title "A Year of Comets" by Mr. Shipley in the August-September number of POPULAR ASTRONOMY now bids fair to be realized. At that time not a single comet had been discovered this year, but during August three were picked up.

First, Kopff's comet of short period was found by Gonnessiat of the Algiers Observatory in the southern part of the constellation Aquila. The date of the discovery is missing from the cablegram announcement, but it was prior to August 7. This comet is very faint, barely visible in our 5-inch finder, and so will hardly be seen by the amateur. It is moving slowly eastward through Aquila and by the end of October will be in Aquarius, about 8° west from the star β.

The second comet was discovered by Rev. Joel H. Metcalf, while on his vacation at Camp Idlewild, South Hero, Vermont, on August 20 at midnight. Its

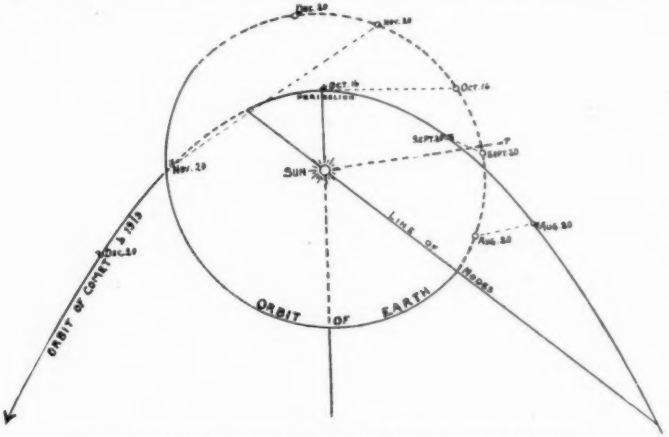

FIG. 1. DIAGRAM OF THE ORBIT OF COMET *b* 1919 (METCALF).

position was then approximately $22^h\ 48^m$ in right ascension and north 25° in declination; magnitude eight. It was thus in the constellation Pegasus, seen in the eastern sky in the evening. Since then it has moved rapidly across the heavens, passing through the constellations Lacerta, Cepheus, Draco, Ursa Minor, Ursa Major and Canes Venatici. During October its course will be south-eastward through Leo and Virgo. Unfortunately this part of the sky is in the vicinity of the sun so that it will be difficult to obtain observations of the comet in October, and then only in the morning just before sunrise.

The accompanying diagram shows the relation of the orbit of the comet to that of the earth. It will appear from an inspection of the diagram that the comet was nearest to the earth about the tenth of September and that now it is receding rapidly. For a few nights about September 15 it was visible to the naked eye. A faint tail could be seen extending a half degree or more from the head.

The diagram was prepared with the aid of the preliminary elements, given below, computed by J. M. Vinter-Hansen and J. Fischer-Petersen of the University Observatory at Copenhagen. A comparison of these elements with those of the comet discovered by Brorsen in 1847 (1847V), which is one of the so-called Neptune family of comets, indicates a very probable indentity of the two comets. The period calculated for Brorsen's comet was quite uncertain, two orbits by Gould, from three normal places, giving 71 and 81 years. If Metcalf's comet is identical with Brorsen's, the period is about 72.1 years.

PARABOLIC ELEMENTS OF COMET *b* 1919. ELEMENTS OF COMET 1847V.

T	=	1919 Oct. 16.1984 G.M.T.	1847 Sept. 9.5583
ω	=	128° 33′.32	129° 22′
Ω	=	311 22.93	309 48
i	=	19 58.03	19 08
$\log q$	=	9.68280	9.6884

The following observations of comet *b* 1919 are all that have come to hand:

OBSERVATIONS OF COMET *b* 1919 (BRORSEN-METCALF).

G.M.T.	R.A. h	m	s	Dec. °	′	″	Observer	Place
Aug. 21.6977	22	48	33.4	+26	48	40	Barnard	Yerkes Ob.
22.4900	22	46	49.5	+28	22	53	Giacobini	Paris
22.7060	22	46	17.0	+28	50	46	Bower	Hashington
22.7551	22	46	10.4	+28	57	04	Jeffers	Lick Ob.
23.5993	22	44	00.1	+30	47	39	Barnard	Yerkes Ob.
23.7185	22	43	39.0	+31	04	03	Burton	Washington
23.7615	22	43	32.8	+31	09	56	Shane	Lick Ob.
24.3657	22	41	52.6	+32	30	36	Millosevich	Rome
*25.4103	22	38	10.9	+35	12	54	Fischer-Petersen	Copenhagen
25.6296	22	37	28.2	+35	48	28.4	Barnard	Yerkes Ob.
25.7129	22	37	07.5	+35	59	59	Chacón	Tacubaya
26.6904	22	33	07.5	+38	47	52	Gallo	Tacubaya
26.8241	22	32	27.41	+39	15	53.8	Barnard	Yerkes Ob.
28.7682	22	21	40.17	+45	24	04.4	Barnard	Yerkes Ob.
30.6703	22	05	56.85	+52	24	14.3	Wilson	Northfield
30.8136	22	04	23.09	+52	56	34.5	Barnard	Yerkes Ob.
Sept. 15.6357	12	28	15.09	+52	22	00.6	Wilson	Northfield
17.6288	12	16	21.07	+47	08	54.4	Wilson	Northfield
22.5836	11	59	11.52	+37	25	04.9	Wilson	Northfield

The third comet was discovered by Rev. Joel H. Metcalf at Camp Idlewild, South Hero, Vermont, on August 22 at 11 p. m. and independently by Borelly at Marseilles, France, on August 23 at $9^h\ 55^m$. This comet is fainter than Metcalf's first comet, but is easily picked up with a small telescope and may be observed during October.

The diagram, Figure 2, shows that this comet is far from the earth and that it will not be much nearer. Had it come to perihelion four months earlier it

*Mean place 1919.0.

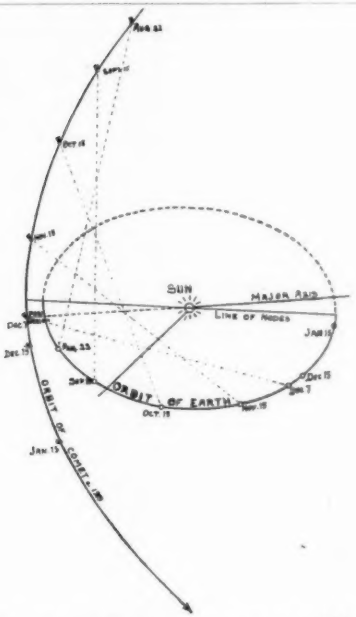

FIG. 2. DIAGRAM OF THE ORBIT OF COMET *c* 1919 (METCALF-BORELLY).

would have been a much more conspicuous object. This diagram was prepared with the aid of the elements, given below, by Everett I. Yowell, which appear to fit the observations quite closely.

The following observations of comet *c* 1919 are all that have come to hand:

OBSERVATIONS OF COMET *c* 1919 (METCALF-BORELLY).

G.M.T.	R.A.			Dec.			Observer	Place
	h	m	s	°	′	″		
Aug. 22.61	14	05		+27			Metcalf	South Hero, Vt.
23.423	14	04	24	+26	52		Borelly	Marseilles
24.3898	14	05	48.94	+26	29	02.9	Michkovitch	
24.6080	14	06	19.0	+26	23	44	Barnard	Yerkes Ob.
24.7099	14	06	27.8	+26	21	19	Aitken	Lick Ob.
25.3629	14	07	29.1	+26	05	39	Borelly	Marseilles
25.4140	14	07	50.66	+26	04	41	Michkovitch	
25.6329	14	07	54.00	+25	59	11	Bower	Washington
25.6908	14	07	59.5	+25	57	46	Aitken	Lick Ob.
26.3418	14	08	59.2	+25	42	28	Michkovitch	
26.5768	14	09	22.4	+25	36	28	Burton	Washington
26.6125	14	09	25.6	+25	35	27	Gallo	Mexico
26.6644	14	09	30.9	+25	34	18	Aitken	Lick Ob.
30.6215	14	15	55.22	+23	57	25.6	Wilson	Northfield
30.6402	14	15	44.24	+23	56	55.7	Barnard	Yerkes Ob.
31.3596	14	17	08.2	+23	39	03	Strömgren	Copenhagen
Sept. 15.5926	14	44	54.28	+16	59	57.4	Wilson	Northfield
19.6291	14	53	02.78	+15	07	41.6	Wilson	Northfield
22.6247	14	59	18.59	+13	42	30.0	Wilson	Northfield
Oct. 2.3683	15	21	26.04	+ 8	49	05.8	Wilson	Northfield

PRELIMINARY ELEMENTS OF METCALF'S SECOND COMET *c* 1919.

Computers:	Jeffers and Miss Heger Students' Observatory Berkeley, Calif.	E. C. Bower U. S. Naval Observatory	E. I. Yowell Cincinnati Observatory
T =	1919 Dec. 18.91	Dec. 15.80	Dec. 7.31 G.M.T.
ω =	173° 07′	180° 46′	186° 02′
Ω =	108 55	114 22	121 00
i =	47 34	46 58	46 23
q =	1.594	1.334	1.110

Ephemeris of Comet *c* 1919 (Metcalf-Borelly).

G.M.T.	α			δ			log Δ	Light
	h	m	s	°	′	″		
Oct. 11.5	15	43	06	+4	11	43	0.3069	2.40
13.5		48	13	+3	08	14	0.3047	
15.5		53	25	+2	04	16	0.3026	2.58
17.5	15	58	44	+0	59	50	0.3006	
19.5	16	04	08	−0	05	03	0.2986	2.77
21.5		09	38	−1	10	18	0.2966	
23.5		15	15	−2	15	52	0.2948	2.97
25.5		20	57	−3	21	41	0.2930	
27.5	16	26	46	−4	27	43	0.2913	3.18

Light Aug. 24 = 1.00

EVERETT I. YOWELL.

Ephemeris of Kopff's Periodic Comet *a* 1919.

[Continued from A. N. **209** 63 for 12^h G.M.T.]

1919	α true	δ true	log r	log Δ	M.
Sept. 30	20^h 7^m 36^s	−7° 40′.4			
Oct. 2	10 24	38.0	0.283	0.108	11.9
4	13 14	35.2			
6	16 7	32.2	.287	.124	12.1
8	19 3	28.9			
10	22 3	25.3	.290	.141	12.2
12	25 5	21.3			
14	28 9	17.1	.294	.157	12.3
16	31 16	12.5			
18	34 24	7.3	.298	.174	12.4
20	37 35	7 2.1			
22	40 48	6 55.9	.302	.189	12.5
24	44 3	50.2			
26	47 19	43.8	.306	.205	12.6
28	50 38	36.9			
30	54 8	29.3	0.310	0.221	12.7
Nov. 2	20 57 19	−6 22.1			

The magnitude is computed from the assumption that on Sept. 16 the total brightness was 11^m.5. It was estimated so in the 12-inch at the Yerkes Observatory. The correction of the ephemeris was found:

Sept. 24 −30^s −8′.1

G. VAN BIESBROECK.

Ephemeris of Comet *b* 1919 (Metcalf).

[From the following provisional elements computed at Copenhagen.]

T = 1919 Oct. 16.1894 G.M.T.
ω = 128° 33′.3
Ω = 311 22.9 } 1919.0
i = 19 58.0
$\log q$ = 9.68280

True coördinates for 12^h G.M.T.

1919	α	δ	log r	log Δ	Mg.
Sept. 29	11^h 48^m 11^s	+27° 34′	9.798	9.698	5.8
Oct. 1	46 36	25 12			
3	45 38	22 57			
5	45 16	20 48	9.739	9.792	6.0
7	45 31	18 43			
9	46 20	16 40			
11	47 48	14 38	9.695	9.878	6.2
13	49 55	12 38			
15	52 35	10 40			
17	55 48	8 43	9.684	9.955	6.5
19	11 59 35	6 48			
21	12 3 45	4 55			
23	8 16	3 6	9.711	0.019	7.0
25	13 2	+ 1 20			
27	17 59	— 0 22			
29	23 3	1 0	9.764	0.072	7.5
Oct. 31	12 28 10	— 3 33			

The apparent brightness is computed from a naked-eye estimation

Sept. 11 = 5^m.0

The correction as deduced from observations at the Yerkes Observatory is

Sept. 19	+4^s	—0′.5
21	+4	+0.6

G. Van Biesbroeck.

Finlay's Periodic Comet.—This comet has not been seen since its return in 1906. It was subject to strong perturbations by Jupiter in 1909-10, and when it should have returned to perihelion in 1913 it was so badly situated with reference to the sun that it was not seen.

The following search ephemeris was computed by Messrs. Fayet and Schaumasse from the elements which were published in 1913. It shows that the comet in September was well placed for southern observers. We are sorry that no extension of the ephemeris for October has yet come to hand.

Ephemeris of Finlay's Periodic Comet
for Greenwich Midnight.

1919	R.A.	Dec.	log r	log Δ	$1/r^2\Delta^2$
	h m s	° ′			
Aug. 20	17 28 03	— 34 45	0.0833	9.5540	5.31
24	26 36	— 34 58			
28	26 23	— 35 13	0.0623	9.5166	6.95
Sept. 1	27 28	— 35 28			
5	29 51	— 35 46	0.0431	9.4723	9.33
9	33 40	— 36 06			
13	39 00	— 36 28	0.0266	9.4181	12.90
17	46 04	— 36 50			
21	17 55 02	— 37 14	0.0138	9.3502	18.72

The brightness of the comet, which is proportional to $1/r^2\Delta^2$, it will be seen should be rapidly increasing, so that there is hope that the comet will soon be picked up.

Elements and Ephemeris of the Periodic Comet 1911 VII (Schaumasse).— Circular No. 194 of the Marseilles Observatory gives new elements and a search ephemeris for the comet of short period discovered by Schaumasse in 1911. The comet in 1913 passed within the distance 0.35 astronomical units of the planet Jupiter and was subject to perturbations by that planet which advanced the time of perihelion passage about a month. It should be found in the northeast in the morning hours during October.

ELEMENTS.

Osculation: 1919 October 8.0 G.M.T.

$$\left.\begin{array}{rl} M = & 356^\circ\ 12'\ 59'' \\ \omega = & 45\ 47\ 54 \\ \Omega = & 90\ 41\ 21 \\ i = & 14\ 43\ 11 \\ \phi = & 45\ 03\ 18 \\ \mu = & 444''.022 \end{array}\right\} 1920.0$$

The portion of the ephemeris computed for October is given below.

EPHEMERIS.

1919	R.A.	Dec.	log r	log Δ	$1/r^2\Delta^2$
	h m s	° ′			
Oct. 4	9 35 19	+16 55.6			
8	9 52 13	+16 13.6	0.0907	0.2071	0.25
12	10 09 11	+15 26.6			
16	10 26 09	+14 35.5	0.0809	0.1980	0.28
20	10 43 04	+13 40.1			
24	10 59 54	+12 41.0	0.0727	0.1905	0.30

When the comet was discovered in 1911 the quantity $1/r^2\Delta^2$ was 0.28, about the same that it will be during this month.

Search Ephemeris for DeVico's Comet 1846 IV.

[Adapted from an Ephemeris by P. Hügeler. See "The Observatory" July 1917.]

Perihelion	1923 Nov. 20		1922 Nov. 21		1921 Nov. 20		1920 Nov. 20		1919 Nov. 20	
	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.
1919-20	h m	°	h m	°	h m	°	h m	°	h m	°
Oct. 18	16 26	−67.6	16 13	−70.0	15 44	−73.4	14 01	−77.9	9 41	−27.1
Nov. 27	16 53	−67.1	16 49	−69.6	16 41	−73.1	16 06	−79.3	15 49	+21.9
Jan. 6	17 24	−67.8	17 32	−70.4	17 49	−74.2	19 17	−80.7	18 15	+17.5
Feb. 15	17 52	−69.6	18 12	−72.5	19 05	−76.6	23 04	−78.1	18 53	+15.2
Mar. 26	18 03	−72.2	18 36	−75.8	20 03	−80.3	1 48	−71.0	18 36	+17.3
May 10	17 39	−75.2	18 08	−80.1	22 50	−86.1	4 00	−60.1		
June 19	16 43	−76.0	16 20	−81.4	8 23	−86.9	5 34	−50.1		
July 29	15 58	−74.3	15 05	−78.6	10 54	−81.7	6 56	−42.4		
Sept. 7	15 52	−71.7	15 06	−75.3	12 26	−78.4	8 10	−36.6		

Ephemeris of Planetoid (1) Ceres.— The following ephemeris of Ceres, the first of the little planets to be discovered between the orbits of Mars and Jupiter, is taken from Circular No. 195 of the Marseilles Observatory. The

error of this ephemeris on August 12 was -7^s and $+1'.3$, so that observers who are interested in looking up this asteroid ought to easily find it.

EPHEMERIS FOR GREENWICH MIDNIGHT.

Date	R.A.	Dec.	log Δ	log *r*	Mag.
1919	h m s	° ′			
Oct. 6	0 06 44	−16 11.8			
10	03 36	−16 20.0	0.3047	0.4686	7.8
14	0 00 40	−16 25.0			
18	23 57 57	−16 26.6	0.3148	0.4681	7.9
22	55 31	−16 25.0			
26	53 24	−16 20.1	0.3276	0.4676	7.9
30	51 36	−16 12.1			
Nov. 3	50 10	−16 01.1	0.3425	0.4670	8.0
7	49 05	−15 47.3			
11	23 48 23	−15 30.9	0.3589	0.4665	8.1

COMMUNICATIONS.

Saving Daylight in Georgia.—They are having a bad time with the new time under the daylight saving law down in Georgia, according to Congressman Lankford of that state. This is the way he explains it:

"We were in the central time zone and were transferred to the eastern time zone and advanced one hour, and then under the so-called daylight saving scheme we were advanced another hour.

"So now noon comes at 10 o'clock in the morning and 9 o'clock in the evening comes before dark. Many of the good people of my district like to retire by 9 o'clock, but they do not like to go to bed before dark.

"It is all wrong. We now have seven times. We have sun time, the old central time, eastern time, advanced time, incorrect time, no time and bad time.

"If a man says he will call at your office at 2 o'clock, you do not know whether he means at 12 o'clock, 1 o'clock, 2 o'clock, 3 o'clock or 4 o'clock. All depends on the time you have in mind and the time the other fellow has in mind. Every day mistakes are made because of this tangled-up time proposition.

"A man the other day in my district and county at Ambrose, Ga., said that he got out of bed in the morning at 8 o'clock, caught a train at 7:45 o'clock, rode 14 miles to Douglas, Ga., reaching Douglas at 7:30 o'clock, ate breakfast at 7:15 o'clock, made some purchases and caught a train back home at 7 o'clock, and got back home at 7:30 o'clock. According to our different times he was gone from home an hour and a half and got back home 30 minutes before he started."

Aurora and Sunspot.—On August 18, 1919, there was a display of Aurora Borealis. In itself it was unusual, being of long duration and extent. At one place it took on the curtain effect so often seen in pictures of aurorae in the far north. But the chief interest lies not in the display as such, as much as in the date on which it occurred. For this was the second display in less than a month. The first one was on July 23. The difference in date is 26 days, or *approximately the rotation period of the sun.* Knowing the relation between sun-spots and aurorae, I examined the sun through smoked glass. A large spot was clearly

visible. Obviously the spot would be in approximately the same position at the time of the first display. This coincidence would seem to be a strong argument in favor of the above mentioned relation.

TOM WRIGHT.

Fergus Falls, Minn., Aug. 31, 1919.

The Aurora of September 18, 1919.—The aurora first began to be noticeable at 11:00 P. M. (summer time). Beginning as a slight luminous haze, which at first did not change in form very quickly, the aurora soon began to manifest rapid variations. Low in the north hung a dense black mass of clouds. The aurora played behind these clouds lighting them up quite brilliantly at times. By 11:45 P. M. streamers had begun to appear and the aspect of the display changed rapidly. Very narrow, intensely brilliant, shafts of green light would shoot up about 35 or 40 degrees, quiver a moment or two, and then fade away as quickly as they came, only to be replaced by others as bright as the first. These narrow streamers seemed to be a feature of the display sometimes four or five shooting up at almost the same time, and very close together. I do not recall ever seeing such narrow beams of light during an auroral display before.

At 12:02 A. M. a brilliant red meteor flashed across the sky towards the northeast, contrasting greatly with the luminous green background. Some of the larger stars, as α and β Ursae Minoris and η Draconis, continued to be visible through the hazy light, while the fainter stars could not be seen at all. At 12:09 A. M. another meteor, bluish white in color, appeared, and at 12:14 A. M. another one, of a more greenish tinge, flashed up. Both traveled with terrific velocity towards the north and burnt themselves out. By 12:25 A. M. the aurora had practically ceased, except for a very faint glow in the extreme north.

A small but delicately balanced magnetic needle showed marked fluctuations during this display, giving evidence of changing lines of magnetic force through the earth. The next morning, September 19, I examined the sun, but no large spots were visble. This aurora was, it seemed to me, the most pronounced and characteristic one seen in this locality during the present year.

LEWIS J. BOSS.

North Scituate, R. I.,
September 19, 1919.

Sunset of Venus.—About two years ago I had an experience which I believe is worth relating. It was on the transport *Henry R. Mallory*. We were homeward bound from France, approaching the Grand Bank of Newfoundland, in about Latitude forty-five, Longitude forty-two. It was the twenty-third of August, nineteen seventeen. The next day I wrote in my note-book a description of what I had seen. I am glad I did. I copy it:—

> Last night I witnessed an unusual and interesting occurrence. I had never seen anything like it before. I don't know if anything like it has *ever* been seen or heard of before.
>
> It was at the beginning of the first watch, a little after eight o'clock in the evening. The sun had set about an hour before, the sunset being unusual and beautiful, extending half way around the horizon, and showing many striking and changing cloud effects, with delicate and lovely tints and shades of coloring. The atmospheric condition was such as to produce an amount of diffraction and refraction of light rarely seen. The moon was about six days old, and showing dimly thru the clouds.

Suddenly Venus, only six or eight degrees above the horizon, came out from under a strip of low-lying cloud. The Third Officer and I stood on the wing of the bridge, watching Venus and talking. The bridge lookout saw the light, and asked us if it were a vessel's light or a star.

Slowly Venus came down toward the horizon, which was clearly visible. We watched intently to see if she would disappear before reaching the horizon. She remained in sight! Her apparent diameter increased; she took on a reddish glow like the sun at setting. We could see the lower limb make contact with the horizon (naked eye); then when she was half way down, the diameter coinciding with the horizon. Finally the upper limb went under like the upper edge of the disappearing sun. We had watched a veritable "Sunset of Venus."

GILBERT P. CHASE,
Lieutenant Commander, U. S. Navy.

New Orleans, 8 September, 1919.

In a later communication Lieutenant-Commander Chase says:

"In reply to your letter of 19th inst., concerning my article, 'Sunset of Venus,' I am pleased to explain that the Ship's Officer, Mr. Durlam, and I both saw Venus. The lookout also saw the 'star'. Mr. Durlam and I had previously familiarized ourselves with the position and appearance of Venus on this and other voyages. There was never the slightest doubt in our minds as to what we saw—it was the planet Venus.

"No matter what may be the apparent angular diameter of Venus, it always presents a perceptible disc to the naked eye, whether seen in daylight or at night. The apparent diameter of the sun is only about 32', yet at rising and setting it looks as big as a 'house on fire.' With a disc of 12"6, Venus would appear to the sun in the ratio of about 1 to 150. If the horizontal diameter of the sun coinciding with the horizon were divided into 150 equal parts, each part would be large enough to have the appearance of size to the naked eye.

"As to the time of disappearing below the horizon from first to last contact, I did nothing to form an estimate. The mind measures time by the impressions or the state of emotion. A second and a half sounds about right. The disappearance lasted just long enough to get a distinct visual impression of the portion of the disc above the horizon at different stages."

Standard Time.— After October of this year the United States is to have the advantage of standard time, both summer and winter, defined by federal statutes with some semblance of scientific accuracy. The law was originally passed by Congress in March 1918, which undertook to establish a legal definition based on "mean astronomical time" with names and governing meridians as follows:

United States standard eastern time	75 W
United States standard central time	90 W
United States standard mountain time	105 W
United States standard Pacific time	120 W
United States standard Alaska time	135 W

Then as a part of the same law, Congress added to the definition that during seven months including the summer the time should be advanced an hour, thereby upsetting the scientific character of the definition. It was as though we should be required to use foot rules with seven of the graduations mismarked.

By the repeal of the "daylight saving section" of the act, this ambiguity has been removed from the definition, and the remainder of the definition is allowed to stand. In consequence, the advocates of "daylight saving" face a more difficult situation than before they had the law passed, for before daylight saving by advancing the clocks was optional, now it is prohibited.

SAMUEL W. BALCH.

160 Broadway, New York, N. Y.

Solar Halo, May 12, 1919.—On May 12 I saw a beautiful solar halo of (supposed) 22° radius, having a circumscribed halo *a a* extending about 55° on each side, all in brilliant colors, remarkably bright. The broken line was in white, as seen at 1:25 P. M. by the ridiculous new time. The brilliant part, indicated by the full lines, was excellent from noon until 4:30. The upper part,

SOLAR HALO, MAY 12, 1919.

about 10° in length that appears so straight, was brilliant at 8:30 A. M., so no doubt but that the phenomenon was good the most of the forenoon.

The circumscribed halo in white at its greatest distance from the 22° halo was about 2½°, having a length of about 90°. I have never seen a circumscribed halo before. I made a drawing of this beautiful halo right on the spot of observation.

JUDSON W. BRUSH.

Cedar Rapids, Iowa.

GENERAL NOTES.

We regret very much that the issue of this number POPULAR ASTRONOMY has been delayed so many days. This delay is caused by the loss of our regular compositor, and necessary change in the method of making up the forms of the magazine. We hope to have the November number out nearly on time.

Mr. Frederick C. Leonard has been appointed a fellow in astronomy for the year 1919-20 in the University of California.

Mr. W. E. Harper, for over ten years on the staff of the Dominion Observatory of Canada, at Ottawa, has been transferred to the new Astrophysical Observatory at Victoria, B. C.

Capt. H. H. Plaskett, who since the armistice has been studying at the Imperial College of Science, London, under Professor Fowler, has been appointed assistant at the Astrophysical Observatory at Victoria, B. C.

Mr. J. P. Henderson, who has been acting as assistant in Astronomy at the University of Toronto for the last four years, has been appointed assistant astronomer at the Dominion Observatory at Ottawa, Canada.

The Astronomical Society of the Pacific held a meeting on June 19th-21st at Pasadena in conjunction with the meeting of the Pacific Division of the American Association for the advancement of Science, the sessions being held at Throop College. (*Scientific American*, Sept. 20, 1919.)

Temperature at the Center of the Sun.—In a paper in the *Comptes Rendus* A. Vronnet sets forth physical considerations supporting the belief that the temperature at the center of the sun, instead of being millions of degrees, as required by the formula for a perfect gas, cannot be much more than 10,000 deg. Cent. (*Scientific American*, Sept 20, 1919.)

Catalogue of the Zone + 25° to + 30°.—An enlarged edition of the Cambridge (English) Catalogue of 14,464 Stars in the Zone + 25° to + 30° has just been issued from the Cambridge University Press. This edition contains the results of the individual observations upon which the first edition was based and of additional observations which have been made since 1897 in revision of the zone.

Mr. Latimer J. Wilson desires that the statement in General Notes of the August-September number of POPULAR ASTRONOMY concerning himself be slightly altered. While in Rochester, N. Y., he has never been employed by the Eastman Kodak Company. His astronomical work during the 1918 opposition of Mars was conducted at the former Bausch and Lomb Observatory through the courtesy of Mr. Geo. N. Saegmuller of that company.

Variable Proper Motion of R Lyrae?—Mr. H. Kienle, of Munich, Bavaria, in *A.N.* 4996 raises the question of the variability of the proper motion of the variable star R Lyrae. From many observations between 1908 and 1919 he finds an apparent oscillation of about $0^s.30$ in the observations of the right ascensions, as compared with the regular proper motion progression. The period of oscillation appears to be in the vicinity of five years.

Catalogue of 7412 Stars.—Volume 5 of the publications of the Observatory of La Plata contains a catalogue of 7412 stars in the zone −52° to −57° for the epoch 1925.0. The observations were made by Mr. Paul T. Delavan, with assistants to read the circles and record observations. The catalogue is arranged on the plan of the Astronomische Gesellschaft catalogue, and, together with the observations of Director Felix Aguilar in the zone −57° to −62°, extends the series of A. G. catalogues down to −62° of declination.

Wireless Signals during a Solar Eclipse.—An interesting experiment was carried out at the Meudon Observatory during the recent total solar eclipse of May 29. It has been found at Meudon that their wireless receiving apparatus is capable of hearing during the night-time signals from the medium-

powered wireless station in the Island of Ascension in the middle of the Atlantic, which is distant 5000 kms. from Meudon, but signals have never been received during the daytime. This is due to the well-known diminution in the transmission of wireless waves in an atmosphere illuminated by the sun. An attempt was made to hear the signals during totality: although the eclipse was not visible at Meudon, a large part of the region between it and the Island of Ascension was obscured during the course of the eclipse. It was found that signals could be clearly heard during the eclipse, but gradually died away as the shadow passed. In this way the direct action of the solar radiation on the transmission of Hertzian waves is clearly proved. (*The Observatory*, August, 1919.)

American Correspondents of the Bureau of Longitudes.—The French Minister of Education has named as American correspondents of the Bureau des Longitudes, Dr. George E. Hale, director of the Mount Wilson Observatory; Dr. William Wallace Campbell, director of the Lick Observatory; and Professor William S. Eichelberger, director of the Department of the Nautical Almanac, U. S. Naval Observatory.

Tycho Brahe's Observation Books.—The original records of Tycho Brahe's astronomical observations were sold long after his death to the King of Denmark and are now preserved at Copenhagen. A contemporary copy of most of them is at Vienna. This material is now being edited by J. L. E. Dreyer for publication at Copenhagen as volumes X to XIII of "Tychonis Brahe Dani Opera Omnia." Mr. Dreyer expects that his publication will serve to clear up some mistakes about the great astronomer and serve to show how important a part he played in the laying of the foundations of modern astronomy. (*Scientific American*, Sept. 20, 1919.)

A New Source of Ultra-Violet Radiation.—A new source of ultra-violet radiation is reported in the *Schweizerische Elektrotechnische Zeitschrift*. The device involves the use of an alternating current discharge at 50,000 volts between aluminum electrodes 2 mm. apart, and situated under water. It appears that the nature of the water is important to secure the best results. Distilled water should be used and kept running. The ultra-violet spectrum thus produced is said to be continuous, and it has proved of great value in obtaining more complete data on certain absorption spectra. In some cases a number of additional bands have been located. (*Scientific American*, Aug. 30, 1919.)

Fatigue Effect of Selenium Cells.—Some further particulars of the "fatigue effect" in selenium cells are given by Dr. P. Lenard in the *Elektrotechnische Zeitschrift*. Such cells have promising qualities as appliances for measuring light, but hitherto certain difficulties have prevented their general application. Among these may be mentioned the "fatigue" that sets in after exposure to light, which results in a progressive change of resistance, cells in the past having been found to be very erratic in this respect. According to the author this difficulty has been largely overcome in the latest forms of cells. Some of these apparently reached a constant resistance after an exposure of only 45 seconds. (*Scientific American*, Aug. 30, 1919.)

Spectra of the Orion Nebulae.—Mr. V. M. Slipher, director of the Lowell Observatory, has secured long exposure spectrograms of several nebulae in the constellation Orion, which are possibly parts of one great nebulous cloud centering about the trapezium. These objects show considerable variation in the character of their spectra, those nearer the center having many bright, or emission, lines superposed upon a continuous spectrum, with little indication of absorption lines; while those farther from the center exhibit more absorption lines and the emission lines are weaker or even absent. In the case of the nebula N.G.C. 2068, located in a region almost devoid of stars, north and a little east of ζ Orionis, the principal nebular bright lines are missing. The spectrum is continuous, crossed by hydrogen and helium absorption lines, the former series strong, the latter weak, as in advanced B-type stars. The nebula is apparently illuminated by reflected starlight, and possibly absorbs the light of the stars which are behind it.

The Henry Draper Catalogue.—Volume 93 of the Annals of Harvard College Observatory contains the third installment of the Henry Draper Catalogue of stellar spectra. This installment comprises the seventh and eighth hours of right ascension. The numbers run from 53401 to 77872.

The classification of the spectra required for this catalogue was begun by Miss Annie J. Cannon on October 2, 1911, and practically completed September 30, 1915. The total number of spectra classified is 242,093, relating to about 222,000 stars.

In the introduction to this volume Miss Cannon gives a complete list and brief description of the various classes of spectra adopted. This will be a great convenience to the student of stellar spectra.

Standards of Magnitude for the Astrographic Catalogue.—In the Annals of the Harvard College Observatory, Volume 85, No. 1, Miss Henrietta S. Leavitt gives the results of determinations made at Harvard of the photographic magnitudes of a sequence of standard stars in each of 96 regions, selected in the overlapping strips of the zones assigned to the various observatories which took part in making the Photographic Chart of the Sky. Each sequence consists of from 15 to 20 stars, the brightest being from 6th to 9th magnitude, and the faintest a little below magnitude 15. The selected regions are alternately at the even and odd hours of right ascension in the successive zones, so that they are quite uniformly distributed over the sky and are near enough together for convenient use by observers. They will serve as an admirable basis for reducing the magnitudes of the several parts of the astrographic catalogue to a uniform system.

An Interesting Nova.—From an examination of the Harvard photographs, Miss Woods has discovered what appears to be an interesting nova. Its position is R. A. $18^h\ 24^m\ 6^s.2$, Dec. $-29°\ 28'.9$ (1875). It precedes C. DM. $-29°$ 15053 (9.4) by $1^s.9$, south $2''$. A variable star announced by Innes in Circular No. 20 of the Union Observatory is about $2'$ north. The magnitude of the nova before the present outburst was about 14, with small fluctuations, but an increase of three magnitudes occurred in 1901. On April 24, 1919, the magnitude was

about 7. At the present time it is approximately 12. These magnitudes are photographic. The image of the star on a photograph taken on September 13, 1919, is distinctly nebulous.

Photographs of the spectrum, which could probably be obtained with instruments of great power, are much to be desired. (H. C. O. Bulletin 693, Cambridge, Mass., U. S. A., September 16, 1919.)

Wave-length of the Chief Aurora Line.—Mr. V. M. Slipher has recently measured three spectrograms of night skylight, taken with a powerful three-prism spectograph, each with exposures continued over many nights. The last plate was exposed over 100 hours. The three plates yield very accordant values of the chief nebular line, viz., 5578.01, 5578.05 and 5578.08. This differs markedly from the previously accepted value 5571. Brief exposures to the daylight sky during the period of exposure to the aurora furnished a comparison spectrum.

Mr. Slipher has found that the principal aurora line may be photographed with the proper apparatus on any clear night, even when no auroral display is visible, *i. e.*, there is a permanent auroral illumination of the sky. It increases in intensity from zenith to horizon and is more intense in the sunrise and sunset parts of the sky than elsewhere.

Temperature Measurements in Deep Wells.—Mr. C. E. Van Orstrand, in a paper presented before the Geological Society of Washington, has given an interesting summary of the results of temperature measurements in a number of deep wells located in Texas, Oklahoma, Pennsylvania and West Virginia. The apparatus which he devised for making these measurements is accurate within 0.2 or 0.3 deg. Fahr. for depths of about 4,000 feet, while for greater depths the error may rise to 0.5 deg. in some cases. The depth temperature curves are not straight lines, but curves with a marked convexity towards the axis of depth. Thus in the case of the remarkably deep Goff well, in West Virginia, which was drilled to 7,386 feet, the rate of temperature increase varies continuously from 1 deg. Fahr. in 97.5 feet at the surface to 1 deg. Fahr. in 46.5 feet over the interval 6,000 to 7,000 feet. In the Texas and Oklahoma oil fields temperatures at a given depth differ widely from those found in Pennsylvania and West Virginia. The temperature of the oil in two wells near Mannington, W. Va., is 83.2 deg. Fahr. at a depth of about 2,900 feet. In the Ranger field, Texas, the temperature of the oil at 3,400 feet is estimated, from measurements at higher levels, to be about 135 deg. The average rate of temperature increase at the surface for thirteen wells in Texas and Oklahoma is about 1 deg. Fahr. in 51.5 feet, as compared with 1 deg. in 91.5 feet for twelve wells in Pennsylvania and West Virginia. (*Scientific American*, Sept. 6, 1919.)